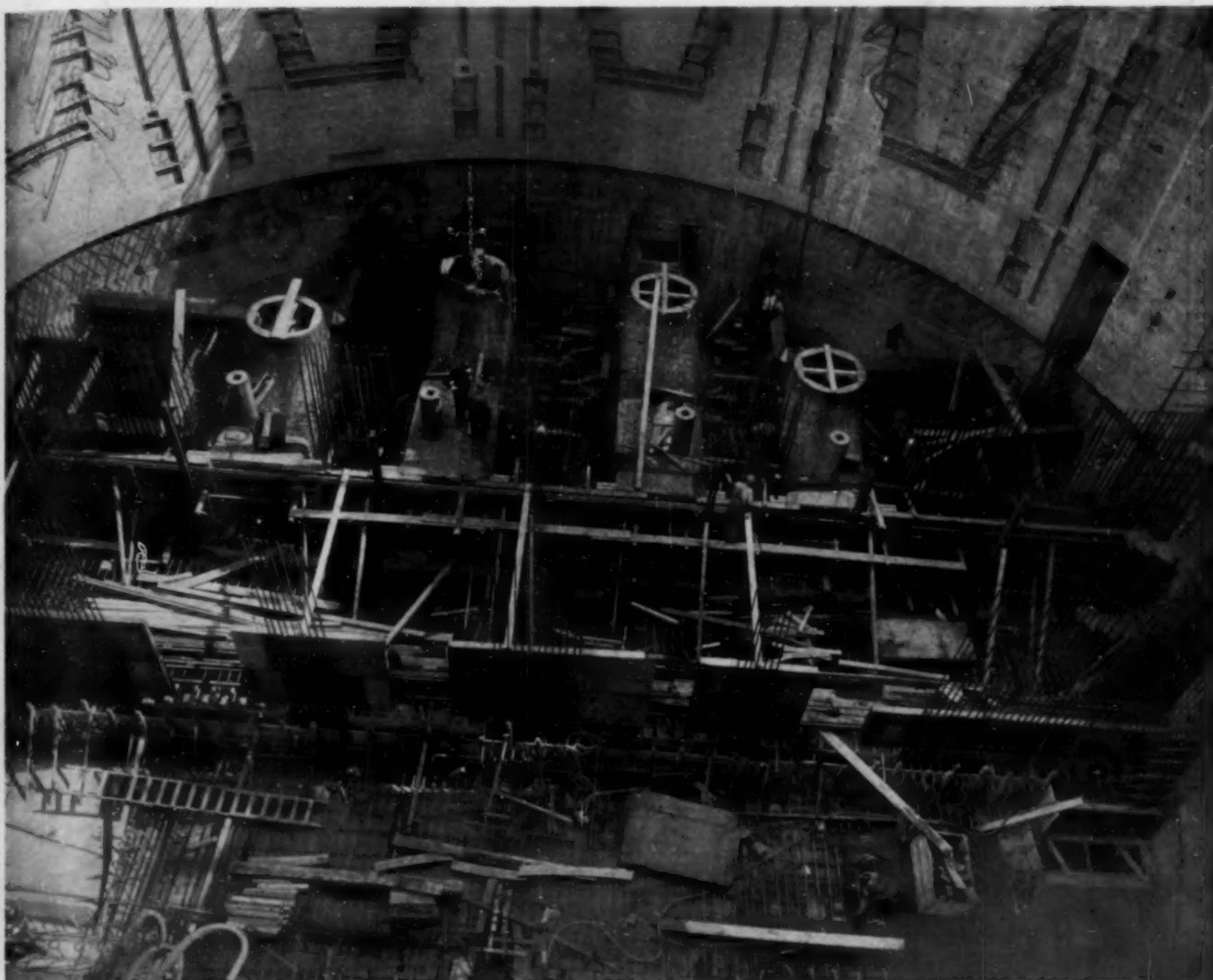
CIVIL ENGINEERING

Published by the American Society of Civil Engineers



FOUNDATIONS OF THE CIRCULAR PUMPING STATION OF THE DETROIT SEWAGE TREATMENT WORKS
A Description of the Plant, with a Full Page of Construction Photographs, Appears in This Issue

Volume 8 — AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 — Number 10

OCTOBER 1938

CIVIL ENGINEERING

Published Monthly by the

AMERICAN SOCIETY OF CIVIL ENGINEERS

(Founded November 5, 1852)

PUBLICATION OFFICE: 20TH AND NORTHAMPTON STREETS, EASTON, PA.

EDITORIAL AND ADVERTISING DEPARTMENTS:

33 WEST 39TH STREET, NEW YORK

This Issue Contains

PAGE OF SPECIAL INTEREST—A Unique Construction Job 5

SOMETHING TO THINK ABOUT

Ethics via Civil Engineering 643
W. E. Howland

MODERN INCINERATOR PRACTICE 645
Harrison P. Eddy, Jr.

DESILTING WORKS FOR THE ALL-AMERICAN CANAL 649
D. M. Forester

SPARTANBURG OUTDOOR HYDRAULIC LABORATORY 653
Howard L. Cook

BRICK LINING FOR IRRIGATION CANALS 656
W. I. Gilson

STATE-WIDE HIGHWAY PLANNING SURVEYS 658
Albert C. Spann and Lee Wendelboe

AERIAL PHOTOGRAPHIC MAPPING BY U. S. GEOLOGICAL SURVEY

Development of Equipment and Methods 661
Joseph Hyde Pratt

Mapping with the Multiplex Aeroprojector 663
W. S. Higginson

THE DETROIT SEWAGE TREATMENT PLANT 667
Clarence W. Hubbell

LINING THE SUNSET RESERVOIR 670
R. B. Rothschild, Jr.

THE HISTORY OF IRRIGATION IN UTAH 672
O. W. Israelsen

THE BARRIER SYSTEM OF FLOOD CONTROL 675
L. M. Winsor

A DECADE OF PROGRESS IN AIR TRANSPORTATION 679
S. R. Newman

ERECTING THE HAWKESBURY BRIDGE, 1887–1889 682
E. K. Morse

ENGINEERS' NOTEBOOK

Analysis of the Positive Surge in a Rectangular Open Channel 685
E. H. Taylor

Photoelastic Analysis of Vierendeel Trusses 686
Max M. Frocht and M. M. Leven

The Other Side of a Flat Right Triangle 688
Leonard C. Jordan

OUR READERS SAY 688

PROGRAM OF SOCIETY'S FALL MEETING 691

SOCIETY AFFAIRS 698

ITEMS OF INTEREST 704

NEWS OF ENGINEERS 705

DECEASED 706

CHANGES IN MEMBERSHIP GRADES 707

APPLICATIONS FOR ADMISSION AND TRANSFER 709

MEN AVAILABLE 10

CURRENT PERIODICAL LITERATURE 16, 18, 20, 22, 25

EQUIPMENT, MATERIALS, AND METHODS 12, 14

INDEX TO ADVERTISERS, ALPHABETICAL AND BY PRODUCT . . 24, 26, 28

The Society is not responsible for any statements made or opinions expressed in its publications.

Reprints from this publication may be made on condition that full credit be given CIVIL ENGINEERING *and the author, and that date of publication be stated.*

SUBSCRIPTION RATES

Price, 50 cents a copy; $5.00 a year in advance; $4.00 a year to members and to libraries; and $2.50 a year to members of Student Chapters. Canadian postage 75 cents and foreign postage $1.50 additional.

Member Audit Bureau of Circulations

Among Our Writers

W. E. HOWLAND, after special studies in sanitary and hydraulic engineering, served with the Sanitary District of Chicago and the Connecticut Department of Health. Since 1926 he has been on the faculty of Purdue University.

HARRISON P. EDDY, JR., graduated from Massachusetts Institute of Technology in 1917, and after two years with the U. S. Naval Reserve Force became an assistant engineer for the firm of Metcalf and Eddy. He has been a member of the firm since 1926.

D. M. FORESTER has been with the U. S. Bureau of Reclamation for 6 years. He is a 1914 graduate of Georgia School of Technology, was an engineer officer in the A.E.F., and for 14 years was in general engineering practice in Central America, the Southeastern United States, and Europe.

HOWARD L. COOK (State University of Iowa, 1929) was employed by Robert E. Horton until 1934, when he went with the Soil Erosion Service—now the Soil Conservation Service. Recently he has been detailed, part time, to review engineering plans for the water facilities program of the U. S. Department of Agriculture.

W. I. GILSON was instructor at Michigan State College, his alma mater, from 1911 to 1917. In irrigation work since 1922, he originated the canal-lining method he describes in this issue. At present he is associated with the Valley Clay Products Company of Mission, Tex.

ALBERT C. SPAN has been with the U. S. Bureau of Public Roads since graduating from the University of Utah in 1928. His work has included design, construction, and collection of cost data, and 2 1/2 years as Bureau Manager of the Utah Highway Planning Survey.

LEE WENDELBOE (Colorado State College, 1909) has been resident engineer for the Utah State Road Commission since 1923, and state manager of the Utah Highway Planning Survey since 1936. Previous experience includes 5 years as junior engineer with the Interstate Commerce Commission.

JOSEPH HYDE PRATT (Yale, 1893; Ph.D., Yale, 1896) was director and state geologist, North Carolina Geologic and Economic Survey, from 1905 to 1924—except during the War years, when he was with the A.E.F., ultimately as colonel and division engineer of the 30th Division. He has served as regional engineer for CWA, FERA, and RA, and is engineer consultant for the U. S. Geological Survey.

W. S. HIGGINSON has been with the U. S. Geological Survey since graduating from the University of Utah in 1928. In 1936 he was selected, with six others, to begin development work with the multiplex aeroprojector, and is still engaged in research and mapping work with it.

CLARENCE W. HUBBELL, senior member of the consulting firm of Hubbell, Roth and Clark, Inc., has been intimately connected with Detroit's sewage treatment problem since 1915. Prior to that time, he was for several years chief engineer of the Bureau of Public Works in the Philippine Islands.

R. B. ROTHSCHILD has been with MacDonald and Kahn Co., Ltd., since his graduation in 1929 from the University of California. He has been in charge of estimating for many large construction jobs, and in 1934 conceived and supervised the manufacture of magnetite (from black sand) for use in concrete for bridge counterweights.

O. W. ISRAELSEN was graduated from Utah Agricultural College in 1912 and has since been engaged continuously in irrigation work—largely research. He is the author of numerous publications on irrigation and drainage problems.

L. M. WINSOR, special consultant on flood control for the Forest Service and Soil Conservation Service, has had long experience in this field, including 28 years in Civil Service and 6 years with the Biological Survey.

S. R. NEWMAN'S career in aviation started in 1931, when he entered the U. S. Military Flying School at March Field. Later he graduated from Kelly Field, and was on active duty for a year before becoming associated with United Air Lines. His present position dates from 1935.

E. K. MORSE has had over 50 years of engineering experience, and has built many large bridges—mostly in the vicinity of Pittsburgh. For 9 years he has been engineer member, Water and Power Resources Board of Pennsylvania. He was "a farmer boy" and an 1881 Yale graduate.

VOLUME 8 NUMBER 10

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

October 1938

Entered as second class matter September 23, 1930, at the Post Office at Easton, Pa., under the Act of August 24, 1912, and accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 5, 1918.

Something to Think About

A Series of Reflective Comments Sponsored by the Committee on Publications

Ethics via Civil Engineering

Sign Posts and Guard Rails on the Road to Truth

By W. E. Howland, Assoc. M. Am. Soc. C.E.
Associate Professor of Sanitary Engineering, Purdue University, Lafayette, Ind.

THEOLOGY and law, the talking professions, have participated through the ages in the development of the philosophy of morals—the theory underlying the rules of human conduct. But we seldom realize that the toiling professions, such as medicine and engineering, have also played a vital part in the pursuit of higher standards of conduct and human relationship.

The civil engineer is essentially a civil servant, he is not merely a technologist working alone and wrestling solely with the forces of nature—no one, not even a pure technologist, is merely that. In the first place, he has himself to contend with and, secondly, he must work with others—perhaps thousands of others, making their work harmonize into a great structure. The rules of behavior the engineer adopts and the skill he develops in administering these rules determine in a very large measure the success of his enterprise. And he knows it! As a result of long (and on the whole) successful experience he has found that character is one of the prime requisites of a good engineer.

Respect for the Truth.~A basic contribution of the civil engineer to the subject of ethics is his discovery of the importance of ethical conduct in his own work. Attorneys may frequently distort the truth, business men may mislead in advertising, and politicians may "exaggerate," but a man who is not fundamentally and completely honest in engineering work is, for that reason, incompetent as an engineer. Engineering belongs to the kingdom of moral law and only its loyal subjects deserve to be called "engineers."

A second contribution of the civil engineer to ethics is the method of education which he has adopted to promote this habitual moral conduct. His scheme for moral development is a thorough training in the scientific method—not training in character building or in ethics as such, but training in the technique of honest thinking. Every well-taught course in engineering is a training in honesty. It is a training in discrimination between reliable and faulty data, a training in accurate and therefore honest measurements, and in the elimination, so far as is possible, of personal errors of observation and judgment; it is a training in the proper use of hypothesis or theory—the discernment of the distinction between the possible, the probable, and the actual; it is a training in caution against hasty generalizations and over-simplifications; it is a training in reasoning correctly from given premises; and finally, it is a training in the art of eternally doubting, and forever inventing new doubts by which to test the validity of one's ideas.

Old-Fashioned Idealism.~The civil engineer has found that there is nothing so practical as a good theory. In many ways old fashioned, he inclines toward the theory that morals are a necessary consequence of the structure of the universe and of the nature of man, which is fundamentally weak and prone to err. Morals are, in other words, the expressions of absolute truth and the necessary guides of men who strive to overcome evil in themselves and to deal justly with their fellow men. He has been brought up on the science of mechanics, the laws of which seem to him for the most part to be absolute and immutable. Some of its rules, he knows, are frankly empirical and temporary, but in his bones he feels that the great foundation science of civil engineering is sound. And so with morals—to him there are certain basic principles of right living and just behavior toward others that are eternally true though they may receive different formulation and application in different ages and in different circumstances.

He is not impressed with the modern view—that men are moved only by selfishness. The engineer knows something about motivation. The sole desire of the bridge builder, for example, is not to finish his bridge and get his pay; he also wants to win recognition amongst his peers. And he must satisfy his conscience with regard to his labors. This motive is closely associated with the social desire to do a worthy thing for the community toward which, as a civil servant, he has a strong feeling of responsibility. There is, also, in his heart the desire for perfection—the urge of the true artist which sometimes finds expression in beauty, in organic beauty of the structure as distinguished from mere ornamentation. There is also curiosity—the scientific motive, the quest for a new and better form of bridge, which is often responsible for progress.

Now these motives are all easily recognizable in engineering work. May we not, therefore, consider these

facts as data which the engineer furnishes the moral philosopher to support a doctrine of the potential idealism of human motivation? Give a man a worthy job and he will frequently respond with his full nobility to its high demands.

He Looks for Error.~But the engineer is also a realist. He has found that the flesh is weak and that there is such a thing as evil in the world. Since he can see no use for evil, he seeks to avoid it. This old-fashioned ethical theory, supported by his experience, was expressed many centuries ago in the phrase, "He who touches pitch will be defiled therewith."

Thus the civil engineer insists upon tests of material coming on the job, tests to reveal hidden flaws, and defective and inferior supplies of all kinds. And when he finds such materials, he rejects and removes them. Likewise he provides for constant supervision of manufacture and construction to detect and avoid poor workmanship. If found, he rejects it.

He is his own severest critic. He checks and rechecks his calculations and then has them checked by some one else to avoid mistakes. And in regard to employees he insists upon examinations and other inspection devices to avoid or reject defective human material.

Exceptions Prove the Rule.~Yet some contractors do bribe inspectors and some politicians and business men do succeed in getting their henchmen employed or even in corrupting the young engineers themselves. "How oft the sight of means to do ill deeds makes ill deeds done!" In general, however, ethical conduct among engineers is the rule. The penalty is too severe—for it is losing caste among one's fellows. This is the individual engineer's first protection against evil—close association in a guild with men who are in the habit of going straight. Engineering has furnished the science of ethics with a practical demonstration of the cumulative power of good examples.

This is not to deny the lamentable fact that there are case-hardened rascals calling themselves engineers who are recognized for what they are by their colleagues—who do evil and seem for a time to prosper thereby. These are the exceptions who prove the rule and bring discredit upon the profession.

Many people do not support the engineer in his insistence upon the notion that evil is to be avoided. "After all," they ask, "what is evil? One man's meat is another man's poison." So by emphasizing the indefiniteness of the line of demarcation between good and evil, they seek to justify wrong doing. Thus they argue that just a little more sand and a little less cement than the specifications require would probably "get by." But the engineer knows that such specifications are to be obeyed to the letter for they are based upon sound reason and reliable tests. A margin of safety must always be provided!

Rule Supplemented by Reason.~This suggests another contribution of the civil engineer to practical ethics. He knows that explicit specifications based upon reliable tests and sound reasoning are of the greatest value in clarifying ethical questions. He is not a slave to the written contract—he does not hold merely to the letter of the specifications but attempts to adhere also to their intent. Being conversant with the laws of nature, he is able to translate into practice the inner meaning of the contract which words alone do not always fully express.

And he knows that, should there be no written contract at all, it is his business to see the job well done and the contractor or workmen paid fairly for doing it. In other words he recognizes his responsibility to be an able minister of sound engineering, not of the letter alone but of the spirit also. The literal interpretation of the human document may be disastrous, but adherence to its intent and compliance with the laws of nature will give permanence and utility to his work.

It is often asked, "How can an engineer hold to a high ethical code and work with those who live on a lower plane?" The answer is to be found in the respect which individually and collectively he may command. This respect is gained only through a rigid adherence to his own self-imposed rules of conduct and a clearly understood limitation of the scope of his responsibility. He will cooperate with others; he will often yield to them on matters of policy; he will compromise on matters of judgment; but on matters of principle in his own field of authority he must be adamant. Better that a bridge or a dam, or even a hospital or a slum-clearance project should not be built at all than that it should be a shoddy structure. He knows that bad means often defeat a good end and are never justified—never, that is, in engineering.

A Judge Among Men.~Finally I should like to mention an almost unique contribution of the civil engineer to ethics—the principle of impartiality. He has made the fundamental discovery that disinterestedness is a necessary condition for straight thinking. He understands the full significance and implications of Pascal's dictum, "It is not permitted even to the most equitable of men to judge in his own cause." Therefore he knows that he should not advertise his own abilities or buy on the statements contained in advertisements. They have for him the hollow ring of special pleading. He knows that he should recommend the purchase of goods solely upon the basis of tests paid for by his client and vouched for by a disinterested third party. He himself may be the disinterested third party who stands between the contractor and the owner in adjusting disputes during construction and in holding the contractor to his agreements. He knows that in order to protect himself against the baser elements of his own nature, and assure himself a respected place in his profession, he should join a professional society with high ethical standards and practices. He knows that his income should be a fee or a wage instead of a commission on sales. It is his obligation deliberately and intentionally to remove from himself all temptation to bias so that he may be as fair and impartial as a traffic light.

The civil engineer speaking to the public tends to argue for the "best plan," to tell the "whole truth" as he sees it—partly because of his education, partly from habit, and partly because it is to his best interest to do so. Of all public servants, not even excepting the judges on the bench, he more than any other falls into an impartial or scientific way of thinking and speaking as a matter of course. And the man in the street accords him this reputation. Such a name must be preserved, for without it the engineer may not serve as the guide which our increasingly technological civilization so urgently needs.

Henry E. Riggs
President

George T. Seabury
Secretary

Sydney Wilmot
Editor in Chief and Manager of Publications

Don Johnstone
Assistant Editor for "Civil Engineering"

Volume 8

CIVIL ENGINEERING

October 1938

Committee on Publications
James K. Finch
Chairman
Louis E. Ayres
Arthur W. Dean
C. E. Myers
Enoch R. Needles

W. L. Glenzing
Advertising Manager

Number 10

Modern Incinerator Practice

Design Considerations for Plants Handling Municipal Refuse and Sewage Solids

By Harrison P. Eddy, Jr.

Member American Society of Civil Engineers

Consulting Engineer, Metcalf and Eddy, Boston, Mass.

SOME 600 or 700 cities and towns now dispose of rubbish or garbage, or both, by incineration. In many cases the process has been extended to include solid matter from sewage treatment works. Here Mr. Eddy presents a concise review of current practice in the design of incinerators, taking up in turn the types of furnaces, charging equipment, and grates; the methods of ash handling, preheating of air for combustion, and temperature and draft control. Many valuable comments on general design considerations are included—on control instruments, utilizing waste heat, plant arrangement, and so forth. The article is abridged from a paper presented before the Sanitary Engineering Division at the 1938 Annual Convention.

The primary object of incineration is the sanitary disposal of offensive materials. Burning must take place without creating objectionable smoke or odors, and the residue from combustion must be inoffensive when disposed of by filling waste land, which is practically its only value in this country. The utilization of by-products is limited practically to the production of steam. In the design of incinerators these points should be borne in mind, as well as simplicity and economy of operation, and the provision of satisfactory working conditions for the men.

Until recently, municipal incinerators were built primarily for burning garbage and rubbish. Now, however, municipal incineration has been extended to include the solid matter removed in the separation processes of sewage treatment works. The weight of materials collected, and their character, vary widely in different cities, depending on a number of factors, the two principal ones being the climate and the wealth of the population. In plant design, regard must be had for the characteristics of these materials, as many details are affected by their variation in moisture content, calorific value, proportion and nature of incombustible matter, and so forth. For example, when burning municipal rubbish without garbage or other unusually wet material, it is not necessary to preheat the air for combustion. In burning garbage, however, preheating is desirable. In burning sewage sludge it is common practice to dry the sludge to such a point that it will burn readily either with or without preheated air. The relative proportions of the furnaces and combustion chambers are also affected by the character of the materials. Presence or absence of foreign matter such as wires and metallic objects affect methods of handling.

In the larger cities it is more common to build plants in which the various operations are segregated as follows: The collection vehicles discharge their contents into a receiving bin. From the bin the material is lifted by a grab bucket crane and deposited in hoppers, through which it falls by gravity into the furnaces, at the control of the firemen on the floor below. The ashes are discharged by gravity into vehicles operating on the floor below the furnaces, and gaseous products of combustion pass through the furnace into the combustion chamber, into preheaters if provided, and through the chimney to the atmosphere.

In some smaller plants and in a few large ones, cranes are not used, but the refuse is charged into the furnaces by hand. In many small plants the ashes are raked from the grate on to the floor or into wheelbarrows at the stoking floor level and then pushed by hand to a dump on the premises.

In some cases the ashes removed below the furnaces are discharged into electrically operated or hand-operated

Dumping Floor and Receiving Bin of Incinerator at Cleveland, Ohio
The Capacity of This Plant Is 600 Tons per Day

cars and lifted by skip hoists or elevators to storage bins, from which they are removed for disposal. Hydraulic ash removal has been practiced in some refuse incinerators, and with the homogeneous ash of sludge incinerators pneumatic handling is practicable.

TYPES OF FURNACES AND CHARGING EQUIPMENT

For sewage sludge incinerators, two types of furnace are in more or less common use. One is the multiple-hearth rabbling furnace, adapted from the metallurgical field, taking filter cake (with or without screenings), skimmings, and grit on the top hearth and working it down through the furnace, which it leaves as ash discharged from the bottom hearth. Drying is accomplished on the upper hearths and burning below, with the zone of the most active combustion varying vertically with the rate of firing. The other type of furnace burns dry sludge in the form of a pulverized mixture of filter cake and dry sludge which is blown into the furnace. Sewage screenings, skimmings, and grit have been burned in sludge furnaces, refuse furnaces, and some furnaces designed especially for them.

RECEIVING BIN OF REFUSE INCINERATOR AT ROCHESTER, N.Y.
Receiving Room at Left, Charging Floor at Right

Refuse-burning furnaces consist essentially of the same elements as any coal-burning furnace, modified as necessary for burning this particular type of fuel. Today practically all such furnaces are fed through the top, the refuse dropping by gravity on to a horizontal or slightly sloping grate. The furnace chamber and combustion chamber usually are separated by a bridge wall. It is in the latter chamber that the gases of combustion reach their highest temperature and in which they should be completely deodorized. The furnaces are of two types, constructed, respectively, of fire brick and of steel, the latter type being water-jacketed to provide for cooling. In either case the combustion chamber usually is of fire brick. Special means are sometimes utilized for temperature and combustion control.

Municipal rubbish is of such heterogeneous nature that a continuous-flow method of charging furnaces commonly has not been used, except in those cases where salvage has been practiced prior to incineration. In such plants the material generally has been dumped into storage compartments from which it is raked by hand on to a sorting conveyor, which carries the refuse past a number of men or women, each of whom picks articles of value from the moving material. The tailings from this process are discharged into the furnace. This method of feed has proved reasonably satisfactory, although the labor involved obviously is much greater than in a crane-charged plant. In most cases where it has been tried, salvage has proved to be uneconomical and has been abandoned. The usual method of mechanical charging has been by means of a grab bucket and overhead crane.

With any method of charging it is desirable that the inrush of cold air into the furnace be limited. In crane-fed plants means are usually provided for admitting small charges of material to the furnace at frequent intervals. The charging device consists of a container of about 1-cu yd capacity, and suitable gates. The bottom of the container is closed by a steel plate forming a part of one gate, which takes the impact of falling objects. Under the steel plate is another gate of refractory-lined cast iron, which makes the furnace substantially air-tight and smoke-tight. These two gates are operated simultaneously by the fireman on the furnace floor, either by a compressed-air ram or by a geared motor through line shafting and clutches.

The charging of powdered sewage sludge is conveniently done pneumatically. The charging of filter cake into multiple-hearth furnaces is generally done by means of an inclined belt with a take-off device at the top, designed to admit at regular intervals a small charge with little air.

In Europe, where ashes, garbage, and rubbish commonly are stored in the household and collected together, it is not uncommon to prepare the material for charging by passing it through screens for the separation of fines, intermediates, and coarse objects, the fine material consisting principally of household ashes and dirt. In this country this has not been done satisfactorily, nor has there been much need for it.

Grinding would make rubbish a much more uniform material. The principal difficulties lie in the great number of wires and steel ribbons from wooden containers, steel barrel hoops, and heavy solid metallic objects rather than in tin cans, of which there are also a large number.

GRATES AND ASH-HANDLING APPARATUS

Most grates for refuse are flat, or inclined by raising the rear about 5 to 8 in. above the front, and are designed for hand stoking. In the last 15 years it has become common practice to install a substantial area of the grate in one or more dumping sections, in order that the ashes may be dumped into the ash pit below with the front of the furnace closed, thus eliminating smoke and heat in the stoking room.

An adjunct to the burning grate commonly used in garbage-burning furnaces is a section of drying hearth, generally at the rear of the burning grate. It consists merely of a fire-brick platform on which the garbage has an opportunity to dry until the fireman pulls it forward for active burning. The main purpose of the hearth is

CHARGING FLOOR OF THE ROCHESTER PLANT
Note the Induced-Draft Fans at the Right

to prevent clogging of the grate openings rather than to provide additional grate area. In a number of recent furnaces the hearths have been omitted.

In some furnaces basket grates consisting of steel tubes, water-cooled, hold the refuse above the burning grate for a drying period, after which it falls off or the fireman rakes it off to the burning grate below.

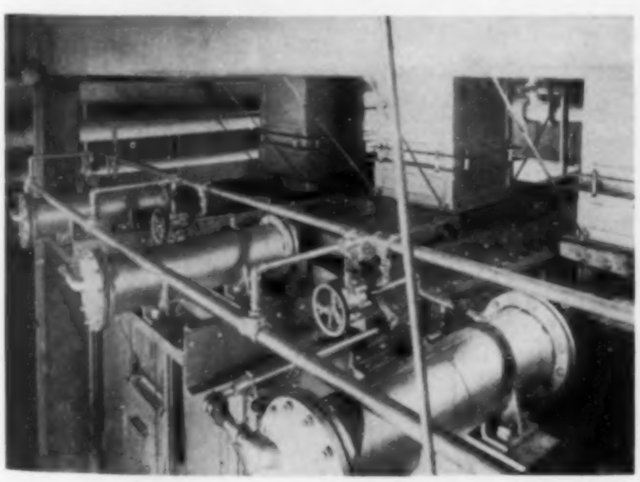
No installations of chain grate stokers have been made in the last few years. With chain grates it is necessary to give particular attention to the design of the charging devices and to the control of the air supply, since with a heterogeneous material some parts of the grate may be covered with a thick fuel bed and others with a thin one. Also, some parts may have wet fuel and others dry, fast-burning material. These conditions make air and combustion control difficult. Wires and molten glass break the moving grate fingers and frequently necessitate minor shutdowns.

Although probably the greatest improvement in working conditions in modern incinerators came about through the installation of dumping grates, this of itself merely transferred the uncomfortable conditions from the fire room to the ash-removal room or ash tunnel, frequently ill-ventilated, on the floor below. In recent years, however, provision frequently has been made for quenching with water the ashes in the ash hoppers under the grates. When thoroughly quenched, the ashes as dumped into the removal vehicle are cool, wet, and free from dust. Even with quenching, however, large volumes of steam may be given off in the ash tunnel and on this account such compartments should be thoroughly ventilated.

Gates of various types have been used for discharging ashes from the ash hoppers—from a simple vertical steel plate hinged and latched on opposite sides and operated by hand, to water-sealed, mechanically operated, horizontal gates. Mechanical operation can be accomplished by compressed air, water, or by oil under pressure.

AIR SUPPLY AND PREHEATING

When burning mixed refuse, it is common practice to operate under forced draft with preheated air. If the source of air is within the building, it must be borne in mind that in winter any large volumes of inside air thus displaced will be replaced by cold outside air, and provisions should be made so that such replacement will not create seriously objectionable drafts on the operators. In summer it may be advantageous to take the forced-draft supply from the top of the stoking room, in order to reduce the temperature of this working space. Commonly the air for combustion is drawn from the interior of the building at all seasons of the year, except in the coldest weather. In a few plants an attempt has been made to collect, through the forced-draft system, the dust arising from the dumping of rubbish.



CHARGING EQUIPMENT LIKE THIS AT ROCHESTER LIMITS THE INRUSH OF COLD AIR

FIRE ROOM OF THE 56TH STREET INCINERATOR, NEW YORK, N.Y.

With multiple-hearth rabbling furnaces forced draft is used, the air supply first being used for cooling the rabble arms, and the central shaft about which they revolve, and then for combustion. With furnaces in which waste heat is utilized in generating steam, it is usually the practice to provide induced-draft fans, both for overcoming the additional draft due to the boilers, and to some extent for better control of the draft.

When the fuel is high in moisture, drying and combustion are facilitated by heating the air supply. Since few municipal incinerators utilize waste heat, the air heaters receive the gases at high temperature, and must therefore be of such design that the materials subjected to the gases will have a reasonable life. Several types of preheaters are used.

Tubular heaters with gases passing through the tubes and air around the tube bank are made of steel and cast iron with tube sheets of cast iron. In a few cases recently, this type has been made both with heat-resisting alloys and with silicon carbide tubes. Plate-type heaters are commonly used after the gases have been chilled by passing through boilers, but this type is not suitable for hotter gases.

A mixing type has also been used in which hot gases are mixed with air for combustion in such proportions that the desired degree of preheat is obtained. The revolving regenerative type of metallic heater has been used in a few cases but so far as the writer knows, only with pulverized-sludge furnaces. However, this type frequently is included with others in specifications for heaters in refuse incinerators.

While the refractory tile regenerators of the steel industry have not commonly been used in incinerators, tile heaters have been used, of such design that gases pass through a set of passages adjacent to the air passages, the air being heated by the transmission of heat through the refractory.

Because of the variation in fuel quality, it is important that provision be made for by-passing the air preheaters, in whole or in part, when their use is not required.

In most mixed-refuse incinerators little if any automatic control of temperature and draft is practiced. In

rubbish burners handling large volumes of highly combustible material, it is frequently desirable to provide automatic means for controlling the temperature within reasonable limits, by the admission of cold air. This is done by opening air inlets operated by electric motors controlled by pyrometers. Draft control in some modern plants is secured by automatic operation of forced-draft fans, induced-draft fans, dampers, or all of these.

ASH TUNNEL, ROCHESTER INCINERATOR
Proper Ventilation of This Part of the Plant Is Especially Important

Since most incinerator plants have no waste-heat boilers, it is generally essential to provide the chimney with a complete refractory lining for its entire height. The design of the lining must include provision for rapid changes in temperature. If boilers are provided of capacity adequate to chill the gases, and if they will certainly remain in use throughout the life of the plant, then the lining need not be carried to the top of the chimney.

GENERAL DESIGN CONSIDERATIONS

In incinerator practice the use of instruments varies as it does in power-plant practice. Many small plants have no instruments whatever, and with reasonable operation they perform satisfactorily. Other plants are provided with indicating draft gages and either indicating or recording pyrometers. In some of the newer plants having waste-heat boilers, the instrument board includes draft gages, pyrometers, pressure gages, CO_2 recorders, auxiliary fuel meters, steam flow meters; and watthour meters and water meters are provided elsewhere in the plant. The draft gages may give the pressure under each individual ash pit of each furnace, under the boilers, in the boiler uptake, and in the breeching beyond the preheater. Knowledge of these pressures is important in draft control. Pyrometers may give the temperature of the gases in the combustion chamber and, as previously stated, may be used in connection with the control equipment. The temperature of the air for combustion also frequently is indicated.

To maintain deodorizing temperatures at all times, some provision must be made for burning auxiliary fuel when necessary. For example, in semi-tropical parts of the country it is not uncommon to have one or two weeks of intense rainfall, during which all material delivered to the plant is saturated. Under such conditions deodorizing temperatures cannot be secured unless some additional fuel is provided. This can be done by burning oil, coal, wood, or any other highly combustible material.

The possibility of utilizing the waste heat from an incinerator is appealing, particularly in the larger plants, but its economic justification should be looked into in each case before the practice is adopted. In the last few years it has become somewhat more common than in the past to make refuse collections on only five days a week. Municipal practice may well change so that in the future the five-day week may become the rule rather than the exception. In such cases material would be delivered to the plant at best only five-sevenths of the time. Hence a continuous steam supply or power supply could be obtained for the remaining two-sevenths of the time only by storing refuse or by utilizing an auxiliary source of fuel. Furthermore, experience indicates that few cities collect an even reasonably uniform weight of refuse each day in the week. The difficulty of synchronizing the supply of refuse with the demand for steam should always be considered, for it sometimes is great.

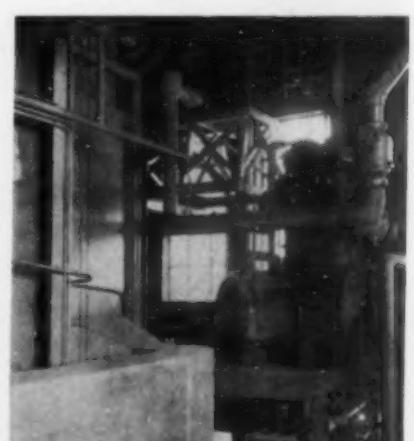
Waste heat has been utilized to produce power for the operation of the incinerator plant itself, or for the operation of municipal asphalt plants and garbage-reduction plants, for pumping water and sewage, and in some cases for the sale of power at dump rates to the local utility. Where waste heat is utilized in the production of steam, the amount of equipment required is of course substantially increased.

From the standpoint of the public it is important that proper consideration should be given to the location of the plant and the architectural treatment of the exterior. Incinerator buildings in general are susceptible of pleasing architectural treatment following the principle that the architecture of a structure should express its utility.

PLANT SHOULD BE PLANNED FOR EFFICIENT OPERATION

Operations at the plant should be segregated for convenient, sanitary, and efficient performance. Vehicles generally should be weighed on arrival. Driveways and dumping facilities should be arranged for the prompt dispatch of vehicles through the plant, so that they will not be held up outside the building. A large receiving room must be provided, preferably completely under cover, to prevent papers and dust from blowing about and to conceal the material, thus removing grounds for objections from neighbors.

In large plants storage should be provided so that the furnaces can be charged at a reasonably uniform rate. The charging floor should be arranged so that the men can work there in safety, without danger of being struck by materials falling from the bucket. The stoking floor should be completely shut off from both the charging floor above and the ash tunnel below, thus keeping its atmosphere free from dust, steam, or smoke. It should be ventilated adequately so as to be a cool, comfortable place to work in hot weather. The ash tunnel should be well ventilated, and provision should be made for preventing the water system therein from freezing. Ample working room should be provided for all operations, including repair and maintenance work about the charging devices, on top of furnaces.



MECHANICAL EQUIPMENT AT THE MANCHESTER (N.H.) INCINERATOR INCLUDES FEEDWATER HEATERS, AIR PREHEATER, AND TURBINE-DRIVEN INDUCED-DRAFT FAN

Desilting Works for the All-American Canal

From an Address Presented Before the Los Angeles Section

By D. M. Forester

Member American Society of Civil Engineers

Engineer, U. S. Bureau of Reclamation, Yuma, Ariz.

Works designed to remove some 50,000 tons of silt per day from Colorado River water entering the All-American Canal are now nearing completion. Settling basins covering almost 30 acres, and 72 rotary-type scrapers each 125 ft in diameter, are the outstanding features of the project. In these pages Mr. Forester explains the economic necessity of providing for silt removal, and describes the desilting works, the underlying principles of their design, and the principal construction methods employed.

Two principal problems have faced the farmers in the Imperial Valley, Calif. These are (1) the erratic nature of the Colorado River, which is the source of their water supply; and (2) Mexican control of their main canal, which looped through Mexican territory for more than 40 miles between its intake and principal feeder canals in California. The Boulder Canyon Act of 1928 authorized both Boulder Dam, for regulating the Colorado River, and an All-American Canal for supplying Imperial and Coachella valleys.

Among the many problems encountered in the studies and design of the All-American Canal system, one was to remove the heavy silt load carried by the Colorado River, before passing the water to the canal, and thus to prevent its deposition in the canal and on farm lands. Contrary to layman belief, the reservoirs formed by Boulder and Parker dams, respectively 300 and 150 miles upstream, will have little effect on the silt content at the headworks for the All-American Canal so far as particles larger than will pass a 300-mesh sieve are concerned. The clear-water discharge from Boulder Dam quickly picks up material from the river bed until the stream is again carrying its normal silt load of sizes available in the channel. Sufficient transportable material exists in the bed and banks to supply the silt load for many years to come, although the amount of fine silt (smaller than 0.05 mm) in the total load may be expected to be considerably reduced. From extensive studies of the silt content of the river, both before and after the closure of Boulder Dam, the general conclusion could only be that for many years in the future a very large volume of silt will be carried into the reservoir created above Imperial Dam—and will require disposal in some manner, for that 85,000-acre-ft basin will soon be silted up completely.

Economics of Silt Removal

Without provisions for removing the silt load from the waters diverted to the All-American Canal, the silt would ultimately be deposited in the main canals and laterals and on the farm lands, and would constitute a serious hazard to the agricultural value of the latter. Studies indicate that the average yearly amount of silt passing the headgates to the All-American Canal during the first ten years of operation will be about 8,200,000 cu yd. It is assumed that some 5,000,000 cu yd of this can be removed by desilting works. If this amount were carried into and deposited in the canal, its removal would in all probability cost as much as 20 cents per cu yd, or $1,000,000 per year. Since the investment in the desilting works may be estimated at about $3,500,000, and the annual cost of operation and maintenance of these works at not more than 1 per cent of their total cost, the savings for the first ten years of operation will more than adequately compensate for the initial investment.

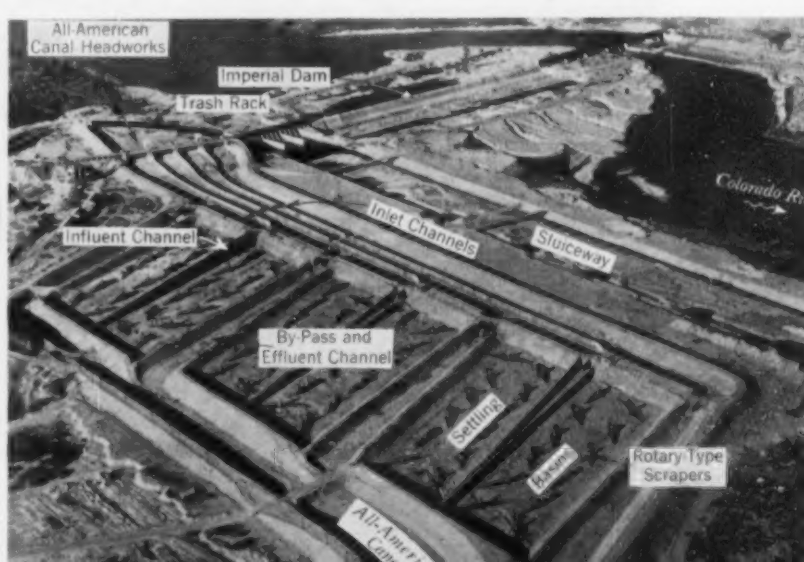
Although the ultimate maximum diversion into the All-American Canal will be 15,155 cu ft per sec, it will be several years before this amount will be required. The design of the present desilting facilities was based on 80 per cent of the capacity of the canal, with provision for the future installation of additional capacity if required.

Studies indicate that after five years of operation more than 19 acre-ft (30,000 cu yd) of coarse silt per day will enter the headgates at the diversion structure when the rate of diversion is 12,000 cu ft per sec, and the volume may eventually reach 37 acre-ft (60,000 cu yd) per day with a diversion of 15,155 cu ft per sec. It is also estimated that the total amount of silt brought into the desilting works during the first ten years of operation will be approximately 50,000 acre-ft, and this volume may eventually be more than doubled before depletion of the available transportable material in the river bed causes a reduction in amounts carried. (C. P. Vetter, M. Am. Soc. C.E., *Engineering News-Record*, March 4, 1937.)

For the purpose of design it was assumed that the incoming silt load for a flow of 12,000 cu ft per sec would be 60,000 tons (dry weight) per day with a maximum of 90,000 tons per day. Deposition rates were calculated and also determined by model studies. With a maximum velocity of 0.22 ft per sec and a detention period of 21 minutes, it was determined that approximately 80 per cent of the maximum incoming silt load would be deposited. The remainder will mostly be finer than 0.05 mm and should not be objectionable in the canal.

As shown on the accompanying photograph, the desilting works consist of a series of six settling basins arranged in pairs. Each basin is approximately 269 ft wide and 769 ft long, with an average depth of 12.5 ft, and is set at an angle of 60 deg with the inlet channel.

At the headworks for the All-American Canal, located at the west end of Imperial Dam, the diversion will be controlled by four roller gates, each 75 ft long and 23 ft high. The main inlet channel, from the headworks structure to the desilting works, is divided into four smaller channels, separated by concrete sheet-piling division walls. The two outside embankments of the main



Air View of All-American Canal Desilting Works

Basins and Channels Between Headworks and Beginning of Main Channel of Canal Cover 92 Acres. Each

Looking Down the Inlet Channels Leading from the Headworks to the Desilting Basins

channel are of compacted earth. This channelization was deemed necessary to maintain non-silting velocities at times of partial diversion, when one or two of the basins are closed down. Each of these smaller channels, except the one nearest the river, leads from one of the roller gates to an influent channel and a combination effluent and by-pass channel. The channel nearest the river will carry water only to the combined effluent and by-pass channel at the downstream end of the works.

The site of the desilting works is a flat, low section of the river bottom which was approximately 2 ft above the normal water surface of the river, except for one hill at the northwest corner of Basin 1. All the division walls of the basins, effluent and by-pass channels, collection channels and canal sections to canal Station 50+00, other than the portion where excavation was required, are compacted earth embankments. The material for them—1,100,000 cu yd in all—was secured from a borrow pit about 2 1/4 miles distant. These embankments vary in height from 12 to 25 ft, have side slopes of 2:1, and are paved with 18-in. dry-rock paving.

DESILTING BASINS AND SCRAPERS

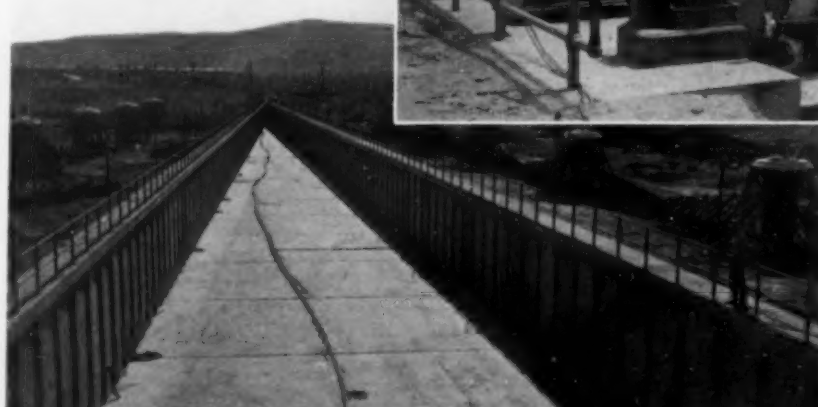
Each basin has a rated capacity of 2,000 cu ft per sec, and each pair of basins is fed by an influent channel, of diminishing cross-section, located between the basins. The influent channel is of reinforced concrete and the water is uniformly distributed to the two basins by flowing through unique vertical slots of special design in its walls(Fig. 1). These slots will serve the three-fold purpose of (1) reducing the velocity and therefore the turbulence of the water entering the basins, (2) distributing the inflow uniformly both as to depth and width of basin, and (3) recovering nearly 0.5 ft of head from the high-velocity water in the channel. The water will flow across the basins to effluent channels leading to the main channel of the All-American Canal.

Each influent channel is controlled at its junction with the inlet channels by twin 21 by 17-ft radial gates. Similar gate installations make it possible to by-pass the flow directly to the combination effluent and by-pass channels and thence to the All-American Canal. Five of the seven gate structures are supported on 32-ft wood bearing piles; the remainder have rock foundations. Steel sheet-piling cutoff walls on each side of the structures extend into the adjoining embankments to prevent any possible piping.

Silt deposited in the basins will be removed mechanically and continuously by 72 rotary-type scrapers, each 125 ft in diameter. These will move the silt into collecting trenches, from which it will be forced into a system of sludge disposal piping, and thence into the sluiceway channel and to the river. The scrapers are specially designed for this type of load. Each unit has a pair of revolving trusses or arms which carry curved scraper blades of special alloy steel, and force or "plow" the deposited silt into the central collecting trenches by blading it into windrows in such manner that each row of material is successively plowed one row closer to the center upon each revolution. The trusses or arms are of the cantilever type, supported from a central concrete pier and rotated by a central driving mechanism.

These arms are triangular in cross-section, having one top chord and two bottom chords. The design includes a special feature by which the depth of the scraper cut is reduced in proportion to any excessive overload. The arms are hinged in two places at their connection to the supporting cage on the driving mechanism—namely, at the ends of the top chord and the trailing bottom chord. The leading bottom chord has no tensile connection with the supporting cage, but simply rests against a bearing plate in compression. Thus when a maximum load is reached, the outer end of the arm carrying the scrapers rises in a backward and upward direction, thus reducing the depth of cut sufficiently to balance the weight of the truss with the horizontal silt load. The truss returns to its normal position as the obstruction is bladed away.

V-shaped plows, fitting into the circular collecting trench at the foot of the center pedestal, bring the sludge (deposited silt) to the four sludge inlet pipes at the pedestals. These inlet pipes extend from the collecting trench through the outer walls of the pedestal and then rise 11 ft. The risers are equipped with two flap-type adjustable valves, one in the elbow at the bottom and one at the upper end, approximately 6 ft below the normal surface of the water when the basins are in operation. Extending through the base of the pedestals, below the inlet pipe, are sludge discharge pipes that are connected with the main sludge collector pipes in the sludge galleries. With the 6-ft hydrostatic head, the sludge is forced from the collector trench through the inlet pipe and into the center well of the pedestal, thence through the discharge pipe to the main collector pipe. Regulation of the valves controls the volume of flow to that necessary to hold the silt content to 10 per cent, the maximum desired concentration. By closing the radial gates of the influent channel and opening the lower valves in the



Above: Typical Influent Channel Gates and Basin Control House

Left: Looking Down One of the Influent Channels (Note the Narrow Vertical Slots Through Which Water Will Pass to Settling Basins)

Above: Combination Effluent and By-Pass Channel

Right: Sludge Gallery Under Construction

risers, each pair of basins can be drained for inspection and repairs.

As the rate of silt deposition decreases with the distance from the influent channel, a greater load of silt will be deposited on the inlet side of the basin than on the effluent. Hence the six machines in the first row in each basin are of somewhat heavier construction than those in the second row, near the effluent weirs. Numerous studies were made of the power required to move and scrape the silt into the sludge-collector trench. Tests indicated that it requires 1 lb of pressure to push sidewise 1 lb of silt (dry weight). Calculated power requirements were checked by models and it was determined that a $7^1/_2$-hp motor would be required on the larger machines, and a 3-hp on the smaller.

The supporting cage for the scraper arms is supported on a ball-bearing ring, 9 ft $6^1/_2$ in. in diameter in the larger machines, and 8 ft 5 $^3/_8$ in. on the smaller, with $1^1/_2$-in. balls. The motors are centrally located over a speed reducer and train of alloy-steel gears to drive the arms and scrapers at 0.08 rpm—hence the speed at the outer ends of the arms will be 30 ft per min. With a deposited load of 70,000 tons of silt per day in the basins, the average amount removed by each scraper in one revolution will be approximately 7.5 cu yd.

The cylindrical pedestals and foundations which support the rotary scrapers are of concrete, placed on rock or cemented gravel—or on concrete bearing piles wherever good foundation material was not encountered at a suitable depth.

The floors of the basins are not paved, the silt being permitted to build up to the lower edge of the scrapers.

The system of sludge disposal consists of cast-iron piping 8 and 10 in. in diameter from the pedestals to the main collector pipes. The main collector pipes are carried longitudinally through the center of each basin in a concrete pipe gallery or tunnel with an inside vertical clearance of 6 ft 6 in. and a horizontal clearance varying from 7 to 10 ft. These galleries, 6 in number, each approximately 1,000 ft long, extend under the inlet channels and embankments and terminate in an access chamber near the right bank of the sluiceway. The sludge pipes through the galleries are of manganese steel, and vary from 14 $^3/_4$ in. in diameter at the upper end to 36 in. at the outlet end. The piping from the access chamber extends through fill to the sluiceway.

Sludge will flow through these pipes at a velocity of 6 ft per sec, and no undue erosion of the pipe is expected. The total sludge discharge into the sluiceway will be approximately 260 cu ft per sec.

The sluiceway channel along the east or river side of the desilting works, with rock-filled dikes for bank protection, will carry the normal excess flow of the river not required for irrigation. Some 6,000 cu ft per sec is estimated as necessary to transport the silt discharged from the desilting basins, and it is calculated that this flow will be available for many years.

The effluent weirs at the sides of each pair of settling basins are of compacted earth fills. They are capped with reinforced concrete, with aprons of the same material extending a short distance down the slopes on each side; the remaining portions of the slopes are covered with dry-rock paving. The crests are of 6 by 12-in. timbers, set in recesses in the concrete and adjustable for minor variations in height.

Each effluent channel is so arranged that it can be used as a by-pass for the diversion of unclarified water around the basins and directly into the canal. Thus, in case of breakdown of the scraper mechanisms, or for other reasons, the canal can be operated without the desilting works.

Controlling the Scraper Mechanisms

Operation of the mechanical scrapers and the radial gates is controlled from a main control house on a hilltop near the California abutment of the Imperial Dam. There are also basin control houses on the embankment, at the upper end of each pair of settling basins.

Three methods are provided for controlling the scraper mechanisms. First, they can be started and stopped individually by push-button switches on the basin control-house board. Second, a master control switch on this board starts four of the scrapers at a time, in sequence, and a master stop push-button switch stops all the scrapers in the basin. Third, a "start" push-button on the main control-house board operates the same sequence starters, and a similarly located "stop" push-button stops the scrapers in each basin. The control for each basin is identical.

Each rotary scraper is protected from overloading by two overload relays—one that gives an alarm when the motor is slightly overloaded, and another that disconnects the motor if a heavy overload occurs. The alarm relay operates a bell at the basin control house and also lights a red light on the scraper mechanism and a white light near the individual motor switch on the basin control-house board. This relay is set at 125 per cent of full load current and opens the motor contactor, stopping the motor when this loading

Each of the 72 Rotary-Type Scrapers Sweeps an Area 125 Ft in Diameter

is reached. Whenever this motor contactor opens, the red light on the scraper mechanism and a red light by the motor switch on the basin control board come on, and a "howler" on the roof of the basin control house sounds.

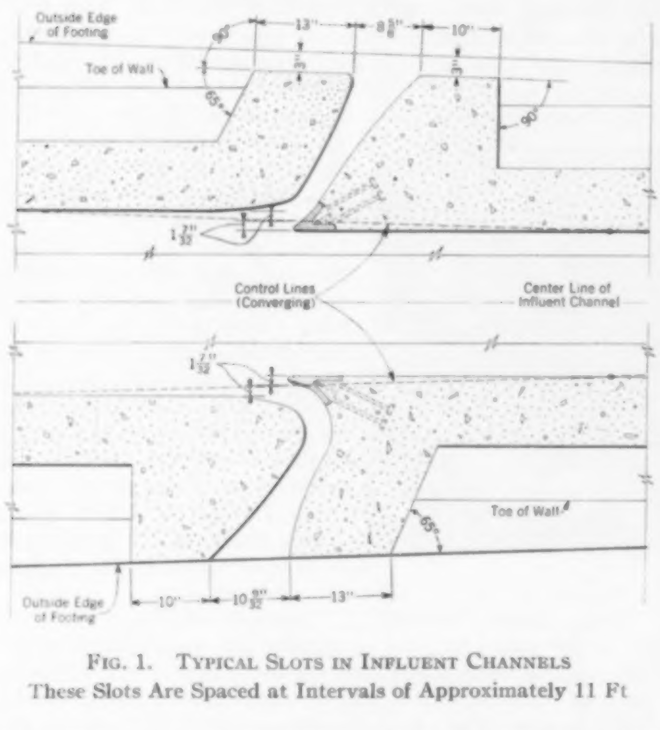


FIG. 1. TYPICAL SLOTS IN INFLUENT CHANNELS
These Slots Are Spaced at Intervals of Approximately 11 Ft

In addition to these controls, a float switch is mounted inside each of the pedestals supporting the rotary mechanisms. This float switch operates whenever the water surface rises inside the pedestal (indicating that the sludge outlet has become plugged), lighting the red light on the mechanisms and the white light by the motor control switch, and ringing the bell at the basin control house.

The influent and by-pass gates at the upstream end of each channel may be operated from the gate structures, the basin control house, or the main control house. The position of the by-pass gates is shown on indicators on both the basin control and main control boards.

Water-level indicators in the main control house show the water surface in the inlet channels, in each basin, and in the main canal a short distance downstream from the desilting works. The water level of the individual inlet channels and each pair of basins is also indicated in each basin control house.

CONSTRUCTION METHODS; THE "ROCK-PICKING" MACHINE

The major difficulties during construction were caused by the high ground-water level and the necessity for dewatering to permit placing concrete for the pedestals and sludge galleries. In some of the pedestal excavation, so much water was encountered that it was impossible to carry the excavation more than about 15 ft below ground surface. At this elevation the material consisted of very compact gravel and boulders, some of the latter being as large as 2 cu yd in volume. After pumping continuously for several days at approximately 6,000 gal per min, there was no decrease in the quantity of water developed. In such cases the concrete was placed by tremie. Dewatering for construction of the sludge galleries and access chambers was accomplished by well-point methods. Special steel forms were used for the sludge gallery, scraper pedestals, and influent-channel wall construction. The concrete sheet-piling diversion walls in the inlet channels were driven with a "skid-rig." This piling has a penetration of 13 ft, approximately 6 ft of which was through backfill from various excavations. The contractor elected to trench through this backfill and drive the remaining distance, and then backfill around the piling to the required channel subgrade.

In the construction of the compacted embankments the contractor used one $2^1/_2$-yd power shovel at the borrow pit; thirteen 8-yd bottom-dump semi-trailer trucks, and four 7-yd end-dump trucks to transport the material; and one 85-hp bulldozer tractor, two sheep's-foot rollers in tandem propelled by one 85-hp tractor, and one water-sprinkler truck on the embankments. The borrow-pit material contained a large percentage of oversize rock, and a special "rock-picking" machine was developed to remove it from the material dumped on the fill. The machine consisted, principally, of a revolving "grizzlie" or cylindrical bar screen set on an incline in a supporting frame mounted on wide-tired wheels. At the front end of the screen a cutting edge or "plow" was fitted, from which the material was ploughed into the revolving screen, the proper sized material passing through the bars and the oversized rock being carried upward and back by spiral webs to a dumping bin at the rear. The bar screen was rotated by an auxiliary engine and the whole machine was pulled by an 85-hp tractor. The machine was large enough to handle approximately one dumped windrow of material in one round trip. The earth work was done by the George W. Condon Company under a subcontract with the general contractor.

The All-American Canal project, of which the Imperial Dam and desilting works are a part, is being constructed under the direction of the U. S. Bureau of Reclamation. The cost of the system has been contracted to be repaid by the Imperial Irrigation District and the Coachella Irrigation District of California. The construction contract for the Imperial Dam and desilting works was awarded to Morrison-Knudsen Company, Utah Construction Company, Winston Brothers Company, known during construction as "M-U-W." The rotary-scraper mechanisms and their electrical controls were furnished, under Bureau specifications, by the Dorr Company, Inc., which, under the specifications, furnished the detail design.

Studies and designs for the Imperial Dam and desilting works were made in the Denver office of the Bureau under the direction of H. R. McBirney, senior engineer in charge of canal design, all designing work being under the supervision of J. L. Savage, chief designing engineer. These engineers are Members of the Society. The designs were reviewed by the All-American Canal Project Consulting Board, consisting of C. P. Berkey, L. C. Hill, Joseph Jacobs, and the late D. C. Henny, Members of the Society; and Prof. W. F. Durand.

All activities of the Bureau of Reclamation are under the general direction of John C. Page, M. Am. Soc. C.E., commissioner, Washington, D.C. All engineering and construction work of the Bureau is under the general direction of R. F. Walter, M. Am. Soc. C.E., chief engineer. L. J. Foster is construction engineer for the project. He succeeded R. B. Williams, M. Am. Soc. C.E., now assistant commissioner of reclamation, in July 1937. The resident engineer for the dam and desilting works is John K. Rohrer. For the general contractor, R. M. Conner, M. Am. Soc. C.E., is superintendent of construction; Karl Collett is assistant superintendent; and C. S. Bradley, Jun. Am. Soc. C.E., engineer. W. C. Cole was general superintendent for the subcontractor on the earth work.

Spartanburg Outdoor Hydraulic Laboratory

Unique Research Station Specializes in Hydraulic Problems Peculiar to Soil Conservation

By HOWARD L. COOK

ASSOCIATE MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS

SOIL CONSERVATIONIST, SECTION OF WATERSHED AND HYDROLOGIC STUDIES, SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

SOIL conservation work presents distinctly new hydraulic problems to the engineer. The steep and abnormally rough channels, the short duration and infrequency of high runoff, and the heavy silt load, all introduce conditions more or less beyond the range of common hydraulic practice. Most important of all, soil conservation structures must be cheap and simple enough for individual farmers to build, yet structurally and functionally adequate for the purpose they are to serve. To aid in solving many of the practical problems involved, the Soil Conservation Service has established the outdoor laboratory described here. In the research now under way at this laboratory, emphasis is being placed on the study of vegetal channel linings, and much valuable information has already been secured.

THE major engineering problems encountered in the conservation of soil and water are those associated with the design of terrace and terrace outlet systems, gully-control works, water-spreading structures, and other works for the collection, conveyance, and disposal of surface runoff. All these differ radically from the hydraulic works common to other fields of engineering; and because conservation engineering is still in its infancy there is a serious lack of information on the hydraulics of such works.

It was early recognized by the Soil Conservation Service that an extensive program of research would be required to fill the need for hydraulic data directly applicable to the design of conservation works. In 1935, therefore, a survey was made to determine the most urgent requirements of the field technicians, and a comprehensive program of research was planned. The establishment of an outdoor hydraulic laboratory near Spartanburg, S.C., constituted the first step in the materialization of this program.

The main body of this paper is devoted to the Spartanburg outdoor laboratory. First, however, we may review briefly the farm hydraulic problems of the conservation engineer and the program of research through which it is hoped they may be solved.

HYDRAULIC PROBLEMS OF CONSERVATION ENGINEERING

Many of the more difficult hydraulic problems of conservation engineering arise in the design of terrace outlet systems like the one shown in the accompanying illustration. It is the function of these works to collect the storm runoff discharged by the terrace channels and to convey it safely from the field. Obviously the concentration of large flows by the terrace system increases the risk of gully cutting. Moreover, terrace outlet channels are usually steep. It is clear, then, that their design is an intrinsically serious problem. The risk involved could be entirely eliminated by the use of a costly artificial lining or by the construction of expensive structures of the type used in many other fields of engineering. But it is in just this matter of cost that the greatest difficulties of the conservation engineer are rooted. His works must be designed so that they will not fail more frequently than is economically allowable; yet they must be cheap and simple enough for the individual farmer to build. For this reason any program of hydraulic research useful to the Soil Conservation Service must emphasize the development of vegetal channel linings and other inexpensive methods of protection not ordinarily utilized elsewhere.

A "MEADOW STRIP" TERRACE OUTLET CHANNEL
These Broad, Shallow Channels Are Usually Planted to Perennial Grasses, and Valuable Hay Crops Are Produced

Certain new and difficult hydraulic problems are also encountered in the design of gully-control systems, water-spreading schemes for flood irrigation, and other works used in soil and water conservation operations. Many of these problems lie outside the range of present practice in hydraulic engineering. This is because of the unusual economic limitations, the relatively small size of the structures, the prominent part played by steep and abnormally rough channels, the short duration and infrequency of high rates of runoff, and the extraordinarily large loads of soil carried by the runoff.

The following list of important problems indicates more specifically the nature of the information required by the conservation engineer:

1. Calculation of the water-carrying capacities of small, steep channels, especially of those lined with grass and other vegetation.
2. Design of "meadow strips" and other broad, shallow channels containing rank vegetation. Little is known of the hydraulic characteristics of such channels.
3. Protection of channels against scour. This entails elaborate studies of the velocities under which specific types of vegetal linings fail, of the effectiveness of various types of drop structures, and of the economics of different systems of protection.
4. Calculation of the capacities of notches and other apertures used in conservation structures.
5. Study of the capacities and hydraulic behavior of drop inlet spillways, drop boxes, culverts, transitions, overflow and channel spillways, and other structures of a similar nature.
6. Design of inexpensive energy dissipators for use below drops and steep chutes.
7. Design of economical gully-control systems. The dynamic actions of integral systems and their ultimate effects have not been systematically investigated, and the engineering economics of such works remains obscure.
8. Prevention of silting in channels, especially those lined with vegetation.
9. Hydraulic design of water-spreading schemes and the structures constituting them.

RESEARCH PROGRAM IS UTILITARIAN

The program of hydraulic research developed to meet the needs of the field or "operations" engineers of the Soil Conservation Service is strictly utilitarian.

Dam, Headworks, and Measuring Weir
A Loud-Speaker System Permits Direct Communication Between Reservoir and Test Site

In planning it every possible line of attack was given consideration. Instead of seeking to make the problems amenable to solution by any single established method, an attempt was made to fit the method to the problem, so as to attain the cheapest and quickest solution possible.

Three principal lines of attack are contemplated in the program. These are:

1. Investigations of the hydraulic works already in operation on the demonstration and research projects of the Soil Conservation Service. In these studies the tests will be provided by the natural flood runoff, and a period of years will therefore be required to complete the research. Some auxiliary tests may be made with a portable hydraulic laboratory, and where possible, works will be especially constructed for observation and "overloaded" with drainage area to insure more frequent tests.

2. Investigations at temporary outdoor hydraulic laboratories similar to the one at Spartanburg. At these laboratories tests under controlled conditions will yield part of the desired information in a short period of time. By establishing such laboratories in several of the more important agricultural regions it will be possible to obtain solutions for those problems that vary with locality.

3. Investigations of certain fundamental hydraulic problems at, and in cooperation with, established state and federal hydraulic laboratories.

Because of lack of funds, it has been possible to establish only one outdoor laboratory and to make a modest beginning in the study of the hydraulic works already constructed by the Soil Conservation Service.

It should be understood that the investigations outlined herein do not constitute the complete hydraulic research program of the Soil Conservation Service, but only that more practical phase dealing exclusively with the farm problems of the operations engineer. The Spartanburg laboratory is given over entirely to this type of work.

The program outlined is a part of the research being carried out by the Section of Watershed and Hydrologic Studies, of which C. E. Ramser, M. Am. Soc. C.E., is head. The hydraulic and instrumentation phases of the work of this section are directed by the writer.

During the summer of 1935, the engineering staff of the Tyger River demonstration project of the Soil Conservation Service, under the direction of J. T. McAlister, then chief engineer of the project, established a temporary outdoor laboratory at the site of the present Spartanburg laboratory. In the summer and fall of 1935 a number of experiments were performed there by R. C. Johnson, M. Am. Soc. C.E., professor of civil engineering at the University of South Carolina, with the assistance of D. W. Cardwell. These studies yielded information of considerable value to the project staff.

The site chosen for the temporary laboratory possessed such excellent physical characteristics that the Division of Research of the Soil Conservation Service was urged to establish a research project there. In 1936, therefore, F. B. Campbell, Assoc. M. Am. Soc. C.E., of the Division of Research, was transferred to Spartanburg, S.C., to take charge of the hydraulic laboratory studies. Under his supervision the temporary laboratory was redesigned and reconstructed; the dam was raised; a steel headgate installed; a high level supply channel constructed; and buildings, telephone service, and other facilities provided.

Description of the Spartanburg Laboratory

The laboratory (Fig. 1) is located in the Piedmont Plateau region of South Carolina on the Tyger River demonstration project area of the Soil Conservation Service. It is about 29 miles west of Spartanburg, and approximately 3 miles south of Tigerville, S.C. The water supply is provided by Beaver Dam Creek—a tributary of the Tyger River—which at the laboratory site falls about 45 ft in a distance of 800 ft over a rock bed. The dam is at the head of the rapids, thus making the hillside below available for experimental work.

The reservoir has a surface area of a little over three acres. With the present measuring weir in place, flows up to 35 cu ft per sec can be obtained for test purposes. With the measuring weir removed, a maximum flow of about 50 cu ft per sec could be obtained, and this rate could be maintained for about 15 minutes with a reservoir drawdown of less than 0.3 ft. Beaver Dam Creek is fed by springs in its upper reaches and has a dependable low-water flow of about 2 cu ft per sec. With this inflow no difficulty is experienced in filling the depleted reservoir between tests.

The flow to the supply channel is regulated by a steel headgate operated by a screw and hand wheel. By adjusting this headgate a steady flow is obtained during tests. A rectangular sharp-crested weir without side contractions was built in the 3-ft channel below the headgate to serve as the standard measuring device of the laboratory. The distribution of velocities in the channel above this weir was determined by current meter, and the rating was calculated by the formula of Schoder and Turner (Transactions of the Society, Vol. 93, 1929, page 999). This rating was checked by installing a special, previously calibrated measuring flume below the weir and simultaneously measuring a series of discharges. The standard weir is used to measure the flow to all experiments close to the dam (a correction being made for leakage in the supply channel), while the calibrated flume is installed immediately above all experiments located at a distance from the dam to provide an additional check.

The supply channel passes along the top of the hillside on which the experimental installations are located. The upper 300 ft of the channel is of rock masonry and the lower 600 ft is of Bermuda sod. Gates are installed in the side of the channel so that water can be drawn off to the experiments.

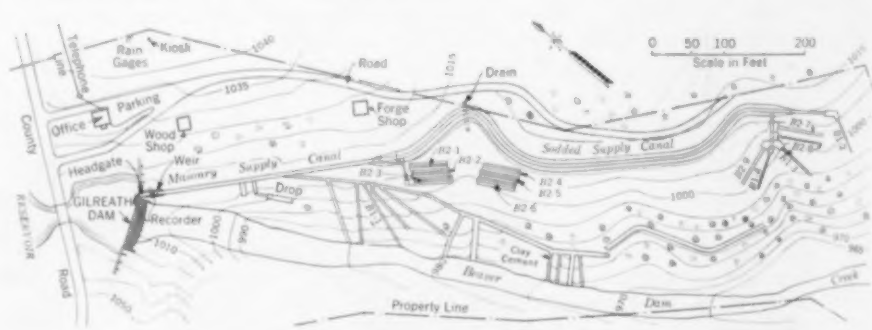


Fig. 1. General Layout of Spartanburg Outdoor Hydraulic Laboratory

Numbers of Test Channels Correspond to Those in Tables I and II

From Fig. 1 it will be seen that about two acres of hillside are available for experimental use. This area affords locations for test channels varying in slope from zero to 30 per cent. The soil of the working space is predominantly Cecil clay.

CURRENT RESEARCH INCLUDES STUDY OF VEGETAL LININGS

At the Spartanburg laboratory emphasis is being placed upon the study of vegetal channel linings. Table I summarizes the characteristics of the channels now being used for this study, and the accompanying photographs show various experimental channels and the forebays and transitions through which water is supplied.

Testing a Channel Lined with Sudan Grass

Studies of artificial linings are also in progress. In 1935 the staff of the Tyger River demonstration project experimented with linings made of soil material stabilized with portland cement. At that time several test channels lined with this so-called "clay-cement" mixture were constructed at the laboratory. These channels, and two installed in 1936, are under observation to determine their resistance to deterioration by weathering.

An investigation of cotton-reinforced bituminous channel linings has been initiated in cooperation with the Agricultural Adjustment Administration. The object of this study is the development of a cheap and lasting type of smooth artificial lining for conservation channels. The reinforcing material is similar to the cotton fabric now widely utilized in road building.

Studies of the capacities of the notches in check dams are also under way. The tests on one type of notch have been completed and a report is being prepared. Experiments with both full-size and model notches were made in this investigation. Other types of notches and apertures will be tested in the near future.

Table I. Channels Used for Studying Vegetal Linings

Channel Number	Type of Lining	Slope, Per Cent	Bottom Width, Ft	Side Slopes	Date of Testing
	Channels Lined with Bermuda Grass				
B1-1	Solid Bermuda sod	30	1.0	1:1	Nov. 1936–Dec. 1937
B1-2	Solid Bermuda sod	20	1.5	1:1$^1/_2$	Summer 1938
B1-3	Solid Bermuda sod	10	1.5	1:1$^1/_2$	Summer 1938
B2-7	Solid Bermuda sod	3	4.0	1:1$^1/_2$	Summer 1938
B2-8	Solid Bermuda sod	3	1.5	1:1$^1/_2$	Summer 1938
	Channels Lined with Meadow Strip Vegetation				
B2-1	Lespedeza Sericea	6	2.0	1:3	Fall 1937
B2-4*	Lespedeza Sericea	6	2.0	1:3	Not tested‡
B2-2	Common lespedeza	6	2.0	1:3	Fall 1937
B2-5*	Common lespedeza	6	2.0	1:3	Not tested‡
B2-3	Sudan grass	6	2.0	1:3	Fall 1937
B2-6*	Dallis grass (Sudan in 1936)	6	2.0	1:3	Not tested
B2-3†	Bare	6	2.0	1:3	Spring 1938
	Channels Lined with Other Plant Covers				
B2-9	Kudzu vine	3	4.0	1:1$^1/_2$	Not tested‡
B1-4	Centipede grass	3	1.5	1:1$^1/_2$	Not tested

* Duplicate Channels for tests of second-year meadow strips.
† Tested bare after completion of Sudan grass tests to provide basis of comparison.
‡ To be tested during summer and fall of 1938.

Table II. Results of Tests on Vegetal Linings
Maximum Test Flows 15 to 16 Cu Ft Per Sec
(See Table I for a Description of the Channels)

Channel Number	Type of Lining	Kutter's n	Probable* Safe Velocity Ft per Sec
B1-1†	Solid Bermuda sod	0.035	8
B2-1	Lespedeza Sericea	0.038	3
B2-2	Common lespedeza	0.037	4
B2-3	Sudan grass	0.033	5
B2-3	Bare‡	0.018	1

* For short periods of runoff with recovery periods intervening; good cover.
† Results for other Bermuda-lined channels not available at time this paper was prepared.
‡ Tested bare to provide basis of comparison.

Another major investigation under way has for its objective the development of cheap methods of protecting the channels below drops and falls of various heights. An adjustable flume has been especially designed for this study, the elevation of which can be changed so as to vary the distance through which the water falls to the erosion pit below.

Additional investigations scheduled for early action include studies of other types of vegetal channel linings; the hydraulics of terrace channels; flow in steep chutes; drop inlets and drop boxes; gully control systems; channel scour and silting; and the capacities of various types of apertures.

Reports on completed research are first issued in mimeographed form for the use of the field engineers of the Soil Conservation Service. The data will be released to the profession at large as soon as possible. Preliminary tests of various types of vegetal linings have yielded information that is summarized in Table II.

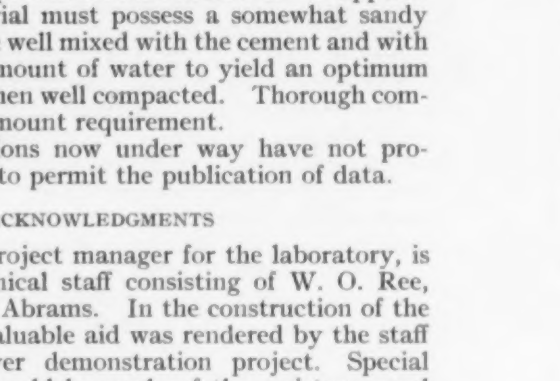
The work on channel linings of soil stabilized with cement indicates that a fairly durable lining can be obtained if the proper precautions are observed. It appears that the soil material must possess a somewhat sandy texture and must be well mixed with the cement and with exactly the right amount of water to yield an optimum moisture content when well compacted. Thorough compaction is the paramount requirement.

Other investigations now under way have not progressed far enough to permit the publication of data.

ACKNOWLEDGMENTS

Mr. Campbell, project manager for the laboratory, is assisted by a technical staff consisting of W. O. Ree, R. L. Burt, and C. Abrams. In the construction of the laboratory much valuable aid was rendered by the staff of the Tyger River demonstration project. Special acknowledgment should be made of the assistance and support of S. L. Jeffords, project manager. Finally, without the unlagging interest and assistance of Dr. T. S. Buie, regional conservator of Region 2 (southeastern United States), it would have been impossible to develop and operate the project.

The hydraulic research described here was formerly a part of the program of the Section of Soil and Water Conservation Experiment Stations, of which G. W. Musgrave is head. The early development of the laboratory was made possible by his active interest and support. The hydraulic research program of the Section of Watershed and Hydrologic Studies was planned with the aid of many technicians of the Division of Operations, particularly T. B. Chambers, Assoc. M. Am. C.E., head of the Section of Engineering.



View of Several Test Channels Lined with Bermuda Grass
Forebay and Measuring Flume in Foreground

Brick Lining for Irrigation Canals

Low Cost, Low Thermal Coefficient, and Adaptability to Semicircular Sections Are Outstanding Advantages of Method

By W. I. Gilson

Associate Member American Society of Civil Engineers
Formerly, Manager, Cameron County Water Control and Improvement District No. 6, Los Fresnos, Tex.

Rough-Shaping the Canal

The use of brick for canal lining may be traced to a storm which wrecked several old structures in the vicinity of Brownsville, Tex., and made available a large supply of brick. The irrigation district with which I was associated had authorized the purchase and salvage of the brick for general use, and I obtained permission to experiment with them in the construction of a 500-ft section of canal. As far as has been learned, this is the first canal lining of its type to be placed in continental North America. A similar lining has, however, been used in one instance in South America to carry water across a peat bog.

There are five general steps in the process of constructing brick-lined canals: the survey, rough shaping, fine trimming, placing brick, and applying the finishing coat.

The survey and staking do not vary materially from methods followed in other types of canal work. For the rough shaping we have used a $^1/_2$-yd drag-line dredge, but several types of trenching machines are also suitable. An attempt is made to excavate within 0.3 ft of the final cross-section. Some extra effort to secure near precision in machine work is warranted, because of the great difference in cost between machine and hand excavation.

After the rough shaping is completed, the final grade stakes are set. These are usually cut from 1-in. by 4-in. stock lumber, and are placed at 25-ft intervals 1 ft out from the edge of the proposed lining. Horizontal alinement is secured by use of a transit, and vertical alinement with a surveyor's level. For convenience in construction, intermediate stakes are also set at $12^1/_2$-ft intervals. The intermediate stakes are accurately located for alinement and elevation by stretching a line from nail to nail on adjacent stakes. Without any sacrifice in accuracy, the stakes on the opposite side of the canal can be set by means of a spirit level mounted on a straight-edge; this routine work can be done by dependable common labor, thus saving much time and expense.

The fine trim is done with a simple and inexpensive device which has been developed in this locality. It utilizes two 2-by-6's resting crosswise of the canal on the grade stakes. At the midpoint of each 2-by-6 a metal eye is attached, to accommodate a $2^1/_2$-in. pipe. Heavy hoes are next attached to the pipe so that as they revolve they cut a true semicircle of diameter representing the outside of the lining. The handle of each hoe is made of two telescoping sections of iron pipe so that the equipment can be used on canals of various sizes by making proper adjustments in length. Set screws are provided to hold the handles at the required length.

In the initial experiment we used standard 2 by 4 by 8-in. brick. It soon developed that there would be certain advantages in another type, and through the cooperation of a nearby manufacturer, a brick of $1^5/_8$ by 6 by 12 in. was finally developed. This was manufactured with four longitudinal cylindrical holes, which saved some cost through lessening of weight, and also permitted the mortar between brick ends to enter the brick for a short distance and act as a dowel pin.

The bottom courses of brick, to an arc of about 60 deg, are put in place with the proper interval allowed for mortar. Comparatively soft mortar is then placed on top and swept into the mortar spaces with a warehouse broom. The remainder of the brick are laid with a trowel. It is important that all brick be thoroughly soaked before use to insure good bond at the mortar joints and with the finishing coat.

In this locality the soils are alluvial and subject to considerable shrinking and swelling with changes in moisture content. This condition is frequently the cause of longitudinal cracks in lined canals. A method was sought to have the crack, if it formed, come in a straight rather than a jagged line. So 1-in. strips of fabric soaked in asphaltum were placed in the mortar joints on each side of, and approximately three courses of brick from, the center line of the bottom of the canal. These then constituted the weakest joints, and any longitudinal cracks that formed tended to follow them. The strip of fabric acted as a hinge joint as the supporting soil changed in volume, and very close inspection is now required to discover the minute longitudinal cracks. In later experiments, the edge of the brick was coated with crude oil applied with a brush as a substitute for the fabric. Results were equally satisfactory and the cost was less.

Fine Trim with Hoes of Adjustable Length

Following closely after the brick masons comes a crew of two men who apply the finishing coat. Cement and sand in the proportion of one to three, with a small amount of lime added, is placed in the bottom

of the canal and thoroughly mixed. Water is added until the mixture is soft enough to be applied with a broom as a coating over the whole interior of the canal. For several days thereafter the parts of the side walls that are not submerged are sprinkled or splashed to insure proper curing.

The principal items of equipment required on a typical brick canal-lining job are as follows: Small drag-line dredge or other trenching machinery; small centrifugal pump and power for same; pipe to carry water from source of supply to the job; storage tank of 10-bbl capacity, or larger; canal-shaping device; small concrete mixer; two vats for soaking brick; tool house, preferably on wheels; three boxes for sand, each to accommodate one truck load; small tools, including shovels and trowels.

More than two million brick have been used in such canal lining since 1933. Some projects have been completed by the use of regular district employees only, while others have been sponsored by the district in cooperation with the WPA as a means of caring for surplus labor. The projects have met with much favor because of the large percentage of the expense which is paid out in wages.

Laying Bottom Courses of Brick
Note Use of Lath for Securing Correct Width of Mortar Space

On one job carried out without government aid, the over-all cost was $0.086 per sq ft. On a WPA project sponsored by us, the over-all cost was $0.1026 per sq ft. This additional cost was due principally to the fact that the WPA wage was higher than the current local wage and that they had their own foreman and timekeeper who were both charged against the project. It will be noted, however, than even under these conditions the unit cost is lower than that usually bid on similar types of construction.

This type of lining has a number of advantages, which may be summarized as follows:

1. It is economical to construct.
2. The equipment is less costly than that used for most other types.
3. A large part of the expense goes in the form of wages.
4. It is adapted to semicircular construction, which is advantageous hydraulically.
5. Fewer transverse contraction cracks form than in most other types of lining.
6. No case has been found where it has buckled in hot weather.
7. Canal capacities can be changed any desired amount merely by lengthening or shortening the handles of the shaping hoes. (For other types of lining, templates are usually made in sizes increasing by 6-in. increments, and construction of canals of intermediate diameters causes added expense.)

Applying the Finishing Coat

Canals varying from 3 to 8 ft in diameter have been constructed by this method. Thicker brick should, in my opinion, be used for all canal diameters above 8 ft. This would be a safeguard against longitudinal cracks forming outside the hinge joint.

Top Course Is Laid to a Straight-Edge to Secure Perfect Alinement

Some investigations concerning brick canal lining remain to be made, but observations to date make us optimistic about its future. No weaknesses have been found. The loss of water by seepage is negligible. The friction coefficient should not vary materially from that of concrete lining.

Experiments are now being conducted to determine the amount of losses by seepage where mortars composed of various combinations of cement and sand were used, and also where cement, sand, and lime mixtures were used for the brick joint material and finishing coats. The test canals are of semicircular cross-section, 4 ft in diameter. Cross-partitions were constructed at 8-ft intervals, and each partition was given an impervious coating to prevent any passage of water between adjacent sections. Soon after completion, the experimental sections were filled with water to carefully marked elevations. Readings were taken at intervals and the canals were refilled to the original elevations after each reading. An evaporation pan and rain gage were set up alongside, so that natural losses or additions could be taken into account. The sections in which one part cement to three parts sand and one part cement to four parts sand, respectively, were used have shown no measurable seepage losses. However, where mixtures of one part cement to five of sand, and leaner mixtures, were used the losses are definitely measurable. It is certain that the working of the mortar with warehouse brooms during construction is very beneficial in securing watertightness.

We believe the mechanical features of the lining process to be fairly well systematized. However, changes may be possible in the size and shape of brick which will effect a further saving in the amount of mortar and decrease the number of masons necessary. In this connection, experiments are now in progress with the use of a special type of brick applied in conjunction with a wire mesh reinforcement.

State-Wide Highway Planning Surveys

Objects and Methods of the Studies Now Under Way in 46 States

By Albert C. Spann

and Lee Wendelboe, Assoc. M. Am. Soc. C.E.

Respectively Bureau Manager, U. S. Bureau of Public Roads, and State Manager of Utah's Highway Planning Survey, Salt Lake City, Utah

FORTY-six states are at present engaged in making extensive surveys of their road systems, with a view to developing adequate data on which to base their highway improvement programs for the next decade or longer. These surveys include exhaustive inventories of existing roads and bridges, traffic studies, analyses of fiscal problems, and statistical investigations of the life of various types of pavement. Objects and methods of these surveys are described in this article, which is an abridgment of a paper on the program of the Highway Division at the 1938 Annual Convention.

IN THE past three years much has been written on the topic of highway planning surveys. It appears, however, that most of this writing has been done by those closely connected with the performance of the work, so that an outline of the history, objects, and methods of this enterprise should still be of interest and value.

The Highway Planning Surveys are a closely coordinated set of fact-gathering projects, set up as a part of the federal-aid highway program in each of 46 states. Their purpose is to assemble facts in sufficient quantity and detail to permit the formulation of an intelligent and economical highway improvement program for the next ten to twenty years. They are designed to introduce the use of complete economic and statistical data into the solution of problems of highway administration.

In 1935 the U. S. Bureau of Public Roads presented to each of the state highway departments the outline of a plan for a state-wide highway planning survey as a federal-aid project. The Hayden-Cartwright Act of 1934 had already made possible the expenditure of federal funds for this purpose, and most of the states immediately expressed their enthusiastic interest in the proposal. Work was undertaken in a few states in the fall of 1935; by May of 1936 at least an organization was set up in 34 states; and at present the work is under way in all states but New York and Delaware.

THE FOUR PRINCIPAL PHASES OF THE SURVEYS

The general plan of the surveys as proposed by the Bureau is being followed quite uniformly throughout the states, although variations have necessarily been made to meet local conditions and to solve local problems. The data are being collected under four general headings:

1. A rural road and bridge inventory, designed to ascertain how many miles of road and how many bridges actually exist in each state, what are their types and conditions, and what roadside culture and other economic and social entities they serve; also, to depict these items on suitable large-scale maps.

2. A traffic survey, the purpose of which is to discover the volume and character of traffic on every mile of rural public road found in the inventory, to obtain data on sizes and weights of commercial vehicles, commodities being carried, and to some extent on the origin and destination of traffic.

3. A fiscal, road-use, and motor-vehicle allocation study, designed to determine the relationship between the use of, and the contribution to the support of, the several highway systems of the state. It seeks first to establish the amounts and purposes of all revenues and disbursements of all political subdivisions in the state, with particular attention to details of collection and expenditure for roads and streets; second, to learn the relative use of the several systems of highways by residents of the several governmental jurisdictions; and third, to discover the actual situs of motor-vehicle ownership and the place of origin of motor-vehicle fees and imposts.

4. A road-life study, the purpose of which is to ascertain from the records of the state highway departments the construction and maintenance costs, and the service life, of each type of highway surface, thus making it possible to forecast future reconstruction and to determine the annual cost of highway transportation.

A fifth phase undertaken in many of the states, although not so uniformly adopted, is a study of the responsibility of the highway in the causation of accidents.

Since the undertakings were in large part new, original methods of procedure had to be devised in many cases. Although the original plans were prepared in the offices of the Bureau of Public Roads, the combined ingenuity of engineers and technicians in all the states has contributed much to the refinement of the methods used.

The inventory data were collected by field parties traveling by automobile. Road distances were measured with the automobile odometer. Surface, roadway, and right-of-way widths were measured with a metallic tape. Directions, ties, et cetera, were read with a pocket compass or a compass fastened to the windshield.

The type and condition of the surfacing were classified by inspection. The location of all drainage structures over 48 in. in span was noted, and bridges of over 20-ft span were inventoried for type, width, condition, clearance, and other items. Sketches were made of railroad crossings, showing grades, angle of intersection, obstructions to sight, and other pertinent facts. The location of all farm houses, dwellings, factories, churches, schools, institutions, and other cultural items was also noted.

It was known at the outset, or discovered very early, that for most states there were no satisfactory maps

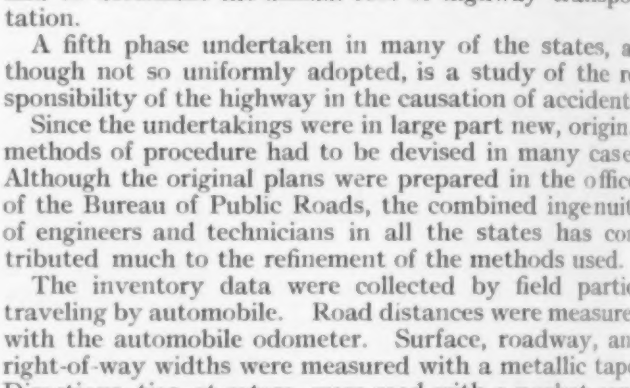
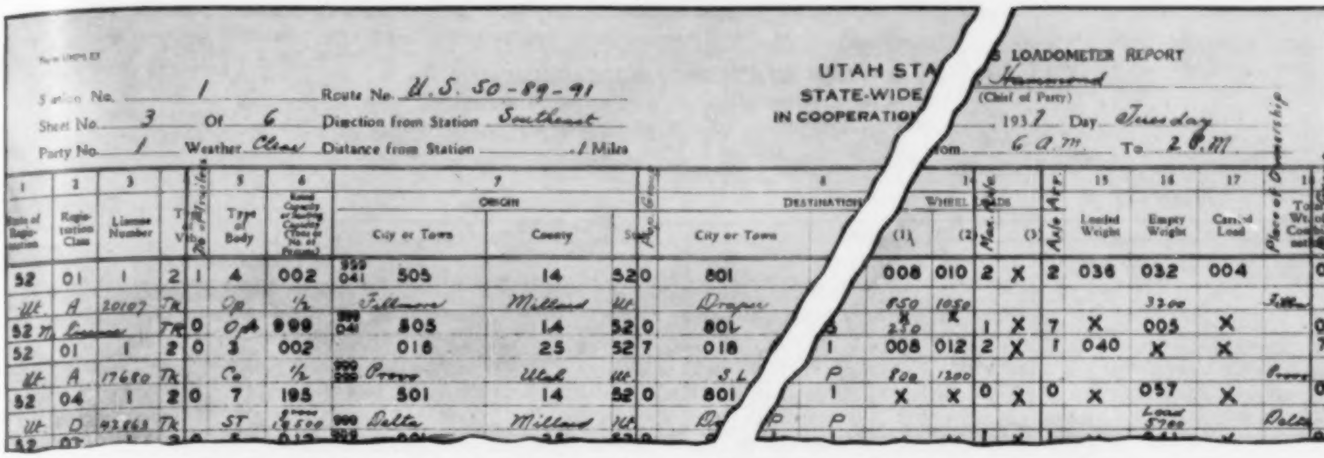


Fig. 1. Factors for Expanding Single 8-Hour Traffic Count (8 a.m. to 4 p.m., Weekday) to 24-Hour Annual Average Traffic Values

Based on 21 Stations on Highways U. S. 89 and U. S. 91



UTAH STA... STATE-WIDE... IN COOPERATIO... ...S LOADOMETER REPORT

Station No. 1 Route No. U.S. 50-89-91

Sheet No. 3 Of 6 Direction from Station Southeast

Party No. 1 Weather Clear Distance from Station .1 Miles

Hammond (Chief of Party)

1937 Day Tuesday

...om 6 a.m. To 2 P.M.

1 State of Registration	2 Registration Class	3 License Number	Type of Vehicle	No. of Trailers	5 Type of Body	6 Rated Capacity	7 Origin: City or Town	County	State		8 Destination: City or Town		Wheel Loads (1)	(2)	Max. Axle	(3)	Axle Arr.	15 Loaded Weight	16 Empty Weight	17 Carried Load	Place of Ownership	Total Wt. of Combination	
52	01	1	2	1	4	002	999 041 505	14	52	0	801		008	010	2	X	2	036	032	004			0
Ut.	A	20107	Tk		Op	1/2	Fillmore	Millard	Ut		Draper		850	1050					3200		Fillmore		
52	M [illegible]		Tk	0	Op	999	999 041 505	14	52	0	801	6	X 250	X	1	X	7	X	005	X			0
52	01	1	2	0	3	002	018	25	52	7	018	1	008	012	2	X	1	040	X	X			7
Ut.	A	17680	Tk		Co	1/2	999 999 Provo	Utah	Ut.		S.L.	P	800	1300							Provo		
52	04	1	2	0	7	195	501	14	52	0	801	1	X	X	0	X	0	X	057	X			0
Ut	D	43863	Tk		ST	[illegible] 500	999 Delta	Millard	Ut.		D[illegible]	P							Load 5700		Delta		

PART OF A LOADOMETER FIELD SHEET, CODED FOR PURPOSES OF MECHANICAL TABULATION

showing a reasonable number of existing roads, nor were there any maps on which the roads could be sketched as found. One of the most important products to be expected from the surveys, therefore, was a set of adequate highway maps. Since this need was so uniformly urgent throughout the states, the Bureau and the states adopted a set of standard conventions and scales. The county was selected as the mapping unit; and the scale generally chosen was one inch to the mile. All land subdivisions and political boundaries, and all roadside culture—in fact everything that could be considered as a possible origin or destination of traffic—were platted. The size of this mapping job may be appreciated from the fact that maps are being prepared comprising 2,894 counties in 43 states, and covering an area of 2,915,170 sq miles.

AN INVENTORY OF SUB-STANDARD SECTIONS OF HIGHWAY

As a special feature of the inventory, a survey was made in each state of the existence of sub-standard sections of the principal roads—that is, the location and extent of sections of the highway on which grades and curves are excessive, and superelevation and sight distance insufficient for modern traffic. Based on speeds of 60 miles per hour in non-mountainous and 40 miles per hour in mountainous country, the following characteristics were selected as desirable: in non-mountainous country, a minimum sight distance of 1,000 ft, maximum curvature of 6 deg, maximum gradient of 5 per cent for 500 ft, adequate superelevation for all curves with a maximum of $1^1/_4$ in. per ft; in mountainous country, a minimum sight distance of 650 ft, maximum curvature of 11 deg, maximum gradient of 8 per cent for 500 ft, adequate superelevation with $1^1/_4$ in. per ft maximum. All sections of road on the primary system that fell below these standards were measured and noted.

Some ingenious methods were devised in several of the states for measuring degree of curvature, length of sight distance, superelevation, and grade. A number of states used specially constructed stadia rods and stadia wires mounted on two cars, and special odometers reading in feet or in hundredths of miles, to obtain the length of sections of road in which they were interested, and specially constructed level vials attached to the cars for measuring grade and superelevation. The most common device for measuring curvature was a card calibrated in degrees and fastened behind the steering wheel. Arkansas developed a special one-wheel trailer attached to a pick-up truck, the connection in the back of the truck being graduated so that the degree of curve could be read directly by a passenger in the truck. Arizona used a device coupled to the drag rod of a car so that the amount of turning of the front wheels was indicated by a pointer and scale in front of the windshield; this device gave greater accuracy than the card behind the steering wheel.

Determination of traffic volume on every mile of road necessitated the development of methods of sampling. The procedure involved three parts. First, a number of key stations were established on the main highways and the more heavily traveled secondary roads. These stations were occupied by enumerators on rigidly fixed predetermined schedules in such manner that in the course of a year the count covered all the hours of each day of the week. Second, a very much larger number of blanket count stations were established at which 8-hour counts were made from one to four times during the year. These stations were so located as to cover substantially all the local roads. Third, at a few selected locations automatic electric recorders were installed to make continuous records.

The key station counts provide sufficient data for an accurate estimate of the total annual travel over the main highways and in addition permit the development of relationships of hourly, daily, and seasonal traffic flow. The automatic recorders provide a 100 per cent sample at a few locations to supplement these relationships. Thus it has been possible to expand the single 8-hour blanket counts to annual average volumes (Fig. 1), so that uniform data result for all sections of road.

Information concerning the origin and destination, commodities carried, and wheel loads of trucks, and the origin and destination of passenger cars, was obtained at selected groups of key stations by stopping the vehicles, questioning the drivers, and weighing the truck wheels on portable scales called loadometers.

Collection of fiscal data involved visits by a group of accountants to the offices of all the governmental units of the state. Information was gathered on assessed valuation, tax levies, income together with its source or purpose, and bonded indebtedness. In addition, calculations were made to show how and in what amounts residents of rural areas and of towns and cities of various sizes were responsible for the payment of taxes, liable for the repayment of debt, and recipients of benefits from expenditures made for the several purposes mentioned. Other analyses of highway expenditures disclosed the amount spent for each type of activity on each system of roads in the rural areas and incorporated places.

Data were also needed on the relative use made of the several road systems by residents of the various rural and urban areas. The road-use study was based on the

Form USHPS-11 Quality Press

UTAH STATE ROAD COMMISSION
STATE-WIDE HIGHWAY PLANNING SURVEY
IN COOPERATION WITH U. S. BUREAU OF PUBLIC ROADS

DENSITY REPORT
KEY STATION
BLANKET COUNT
PRIMARY STATION

STATION NO. 25-804 WEATHER Cloudy DATE 3-29 1937 DAY Mon COUNTY Utah

ROUTE NO. US 91 TO Orem DIRECTION FROM STATION North

				LOCAL VEHICLES										FOREIGN VEHICLES									
				Passenger Cars with Trailers		Trucks					Busses						Trucks						
Hours	Passenger Cars	Bicycle	Pedestrian	House	Other	Light	Med.	Hvy.	Tractor Truck Semi-Trailers	Trucks with Trailers	School	Other	Passenger Cars	Pass. House Cars with Trailers	Other Cars with Trailers	Light	Med.	Hvy.	Tractor Truck Semi-Trailers	Trucks with Trailers	Total
8-9	162	///			/	44	////	///	/	///		//	𝍸 ////				/				230
9-10	165	// ////			///	50	𝍸	//	𝍸	/		//	𝍸 𝍸 𝍸								248
10-11	157	////			///	65	𝍸	//	/	/		/	𝍸 𝍸 𝍸 𝍸			/					256
11-12	165	//	/		//	50	//	///	𝍸	///			𝍸 𝍸 /			///				//	246
12-1	163	𝍸 𝍸 /	///			51	///	//	//	//		/	𝍸 ///			/					233

DATA COLLECTED AT THE COUNTING STATIONS WERE VERY DETAILED

theory that individuals drive their automobiles very much as a matter of habit—their trips are generally uniform from day to day, and any unusual or infrequent trips are likely to be remembered. Following this theory, a number of vehicle owners were interviewed and asked to describe exactly where they drove their cars during the previous year—which routes they followed and how many times they made each trip. Limited experience had indicated that an accurate picture could be obtained from a carefully selected sample of 2 per cent of the passenger-car owners and 5 per cent of the truck owners in each state.

It was also essential that information be obtained on the distribution of vehicle owners who have been largely responsible for the support and use of the highway system. The greater part of these data was obtained from the returns of questionnaires from motor-vehicle owners. Additional information was obtained by letter and by personal interview, and from the files of various state agencies.

The road-life study involved examination of the construction and cost records of each state highway department since the first work was done by the state. Record cards on which were entered all significant data were prepared for each construction contract. Retirements of an improvement or any part of it by subsequent construction were noted on the record card for the original contract. Tables were prepared showing the mileage of each type of surface constructed, retired, and remaining in service each year; costs of constructing and maintaining the various surfaces; and finally, accumulated construction costs and remaining usable investment in each section of road. These tables are used in determining the service life of the several types of surfacing.

SURVEYS WILL HAVE MANY APPLICATIONS

When all the highway survey data have been collected and tabulated, a vast reservoir of facts will be available from which can be drawn the nature, extent, and location of the public road system; the uses to which its various parts are being put; the present and possible future financial structure; the benefits derived by the general public and by particular classes of users; the necessity for and proper order of improvement and extension; the life expectancy and actual value of each section; and finally, a means of estimating the total annual cost of ownership of a complete road system adequate to serve the public needs. It is not within the scope of this paper to discuss in detail the results or conclusions that will be drawn from the surveys, but a few may be mentioned as illustrations.

The maps are of course finding a wide usefulness in the study of improvement programs. Their use will not be confined to highway departments, however, as already they are being sought by public utility companies, trucking companies, advertising agencies, and other branches of government.

The inventory and traffic studies together permit the scientific selection of a secondary system of federal-aid roads in each state, the designation and improvement of which was recently provided for by Congress through appropriation of federal funds.

The location of sub-standard sections of road is enabling the states to eliminate these undesirable spots rapidly and effectively. Special origin and destination studies have revealed the necessity for, and the economic feasibility of, by-pass routes, alternate routes through cities, et cetera.

Studies of truck weights and sizes are revealing some curious things about rated and licensed capacities and actual loads carried. In one state about 25 per cent of the vehicles in one classification weighed more than the gross for which they were licensed, and a considerable number were found to weigh empty more than the loaded gross weight for which they were licensed. Such facts will doubtless affect the content and enforcement of regulatory laws. Also, they point again to the long-needed correlation between vehicle design and highway design, the lack of which has been largely responsible for the rapid obsolescence of our highways.

Through establishment of the benefits derived, it is possible to determine the proportionate share of taxes that should be contributed by urban and rural residents, and how these taxes should be reapportioned for equitable expenditure. It should be pointed out, of course, that the present studies measure only the direct-use benefits, which are not the sole measure of equitable taxation for the construction and maintenance of our highway system.

These few examples of specific or particular uses for the data from these surveys are not necessarily the most important uses, but are given rather as examples to indicate some interesting possibilities. The far-reaching uses of the whole survey in solving problems of highway planning, design, and administration, will doubtless require months or even years to be fully realized. Plans are now being made in many of the states for continuing, on a smaller scale, the work thus begun—so that the methods and principles established can be applied to the solution of other problems as they appear, so that the data collected can be refined to greater accuracy, and so that up-to-date information will always be available.

Aerial Photographic Mapping by U. S. Geological Survey

CONSTANTLY alert to new developments in surveying and mapping technique, the U. S. Geological Survey has been a pioneer in the application of photographic methods to its work. In the first of the following articles, Colonel Pratt traces the experiences of the Survey along this line from the experimental ground photography of 1904 to the highly accurate aerial photography and map-delineating processes of 1938. In the second article, Mr. Higginson describes in detail the principles and operation of the multiplex aeroprojector—the stereoscopic instrument used by the Survey for the construction of contour maps from aerial photographs. These articles, published by permission of the Director, Geological Survey, United States Department of the Interior, are abridged from papers on the program of the Surveying and Mapping Division at the 1938 Annual Convention of the Society in Salt Lake City, Utah.

Development of Equipment and Methods

By JOSEPH HYDE PRATT
MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
ENGINEER CONSULTANT, U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C.

As the U. S. Geological Survey is charged with the responsibility of preparing the topographic contour map of the United States, it is constantly investigating new mapping methods and instruments and revising its mapping procedure. In this connection the greatest advance of the past twenty-five years is undoubtedly the application of aerial photography to the preparation of planimetric and contour maps.

Photographs taken from the ground were first employed in topographic mapping by the Survey in 1904, when two members of its staff, C. W. Wright and F. E. Wright, applied a commercial panoramic camera to topographic surveying in Alaska. In 1907, C. W. Wright had a new camera made according to specifications which he had drawn up, but it did not become available for use that season and soon afterward this work was interrupted by his transfer to another field. Little was then done with the panoramic camera until 1910, when James W. Bagley, one of the topographic engineers of the Survey's staff in Alaska, had an opportunity to use it to a small extent. His experience was convincing as to its merit, and its use in Alaskan surveys steadily increased.

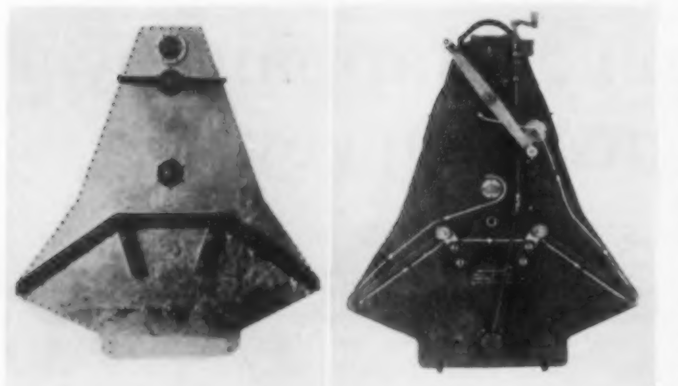
In 1916, Mr. Bagley developed the first multiple-lens aerial camera used in the United States, and Dr. F. H. Moffit, a geologist of the Survey and an associate of Mr. Bagley in the Alaskan work, developed a universal transformer to rectify the oblique negatives to horizontal prints. In 1917, Mr. Bagley was commissioned a major in the Engineer Officers Reserve Corps, and the first photographs with his tri-lens camera were taken at Langley Field in cooperation with the Air Service during the winter of 1917–1918. The results of these tests served as a basis for a program to air-map several strips of country between aviation fields. This work was undertaken jointly by the Corps of Engineers, the Air Service, and the Geological Survey. The activities of the Survey in this field were then curtailed by the War.

The American Expeditionary Forces used this camera in France. Soon after the armistice Major Bagley designed a four-lens camera and later initiated the development of one of five lenses for use in airplanes. Still later (in 1937) R. M. Wilson, M. Am. Soc. C.E., another Survey engineer, designed a new photoalidade for use with oblique aerial photographs, and this instrument has been successfully applied to the mapping of large inaccessible areas in the mountains of Alaska.

The World War focused attention on the value of aerial photography, and many of the 113 topographic engineers of the Survey who served in the military forces brought back observations which aroused intense interest in its application to both planimetric and topographic contour mapping. The war experience of these engineers, in fact, was largely responsible for the Survey's pioneer work in this field.

In the spring of 1920 the West Indies Surveys Division of the Survey inaugurated a systematic aerial photographic survey of parts of Santa Domingo and Haiti, with a tri-lens camera, in cooperation with the Marine Corps. In the same year the Survey made its first successful attempt to map a standard quadrangle by utilizing single-lens aerial photographs for the preparation of field sheets on which contours were delineated by topographers on the ground. The photographs, which covered the Schoolcraft (Michigan) quadrangle, were taken and supplied by the Air Corps. This quadrangle map was issued in 1922. In 1921, the Reelfoot Lake quadrangle of Tennessee-Missouri-Kentucky was surveyed and part of the culture and drainage was taken from aerial photographs.

The estimated savings effected by the use of aerial photographs on the Schoolcraft project were about \$6.77 per sq mile, or \$1,500 for the 15-min quadrangle. The planimetry, on the standard scale, was furnished to the field engineers in the form of a blue lithograph on double-mounted paper for the delineation of the contouring by ground methods. The area was photographed with a single-lens camera in two half-days of flying time. At that time office methods of compiling the planimetry were crude, and the use of single prints was somewhat expensive, but enough knowledge was gained to indicate that the use of aerial photographs would be of material value in topographic mapping not only because of reduced field costs but also because of the additional accuracy obtained in the resulting map.



THE "ORIGINAL" TRI-LENS CAMERA AND ITS MODERN SUCCESSOR

In February 1921, a new subdivision of the Geological Survey was established in the Topographic Branch, designated "Section of Photographic Mapping." The purpose of this section was to investigate the probable usefulness of aerial photographs in making planimetric and topographic maps. It was first successful in the completion of base planimetric maps for use in making standard topographic contour maps, and has continued in this work until the present time. In 1924, after the Photographic Mapping Section had gone into the production of base maps, part of its efforts were turned to the second line of investigation—stereophotography.

INSTRUMENTS EMPLOYING STEREOSCOPIC PRINCIPLES

During the World War and immediately afterwards, several instruments were put on the market with which it was possible to construct semi-automatically complete topographic maps from pairs of photographs taken from the ground or the air with the help of known ground points. In these instruments the photographs were viewed stereoscopically. With a "floating mark" in the field of view, it was possible to follow the features in the stereoscopic model and to raise or lower this mark in proceeding from one elevation to another, the result of these movements being a correct delineation of the terrain, both in plan and elevation.

In 1924, one of these instruments, the stereo-autograph, was brought to this country from Germany and installed in the Survey's offices. Tests showed that it was entirely possible to construct maps from ground photographs if there were three or more known positions and elevations in each pair of photographs, and that the accuracy of these maps was equal to that of maps constructed by ordinary methods. However, because so many known points were necessary for each pair of photographs, and also because aerial photographs with their larger area could not be used, this instrument was not considered economical for American use.

The Geological Survey first began experimenting with the application of stereophotogrammetry to topographic contour mapping in September 1927, when one unit of a stereoscopic plotting apparatus known as the aerocartograph was installed on trial. After a year of experimental work the apparatus was purchased and further tests and experimentation carried out until the spring of 1930, when a definite production project was initiated on a strip survey along the upper Columbia River in the state of Washington, followed in 1931 by a survey of the Lakeport quadrangle, California. However, the Survey's use of aerial photographs in contour mapping did not become assured until 1933, and it was not until 1936, with the introduction of the multiplex aeroprojector, that the value of such methods was definitely established.

The results obtained with this projector, after it had been adjusted and modified by members of the Survey staff, were so successful in contour-mapping of the Tennessee Valley area that the Survey now has 15 of these instruments—all of them in the Chattanooga office.

Experience has shown that with the narrow-angle type of multiplex aeroprojector, a good operator can measure differences in elevation as small as 1.8 ft between well-defined objects on photographs exposed at an altitude of 8,400 ft, and can draw contour lines from the same photographs that will have an error in elevation of only about 3.8 ft. (Map accuracy is usually expressed in terms of the contour interval, as for example in the specification that 90 per cent of the points compared shall not show elevation differences greater than one-half the contour interval.) It has been found that for good results the flight altitude should be about 600 times the contour interval.

These investigations have been conducted principally from the Survey's Chattanooga office, but the Survey is now contemplating the purchase of additional equipment to be assembled at other offices of its Topographic Branch.

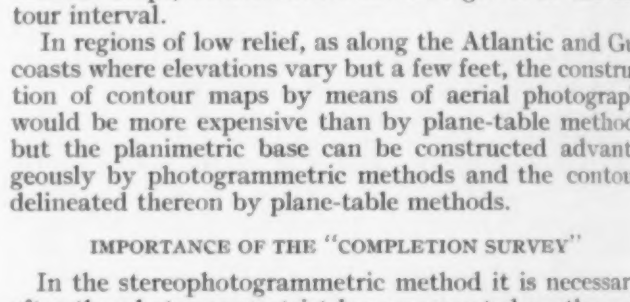
In the aerial photographic method of contour mapping, the contour interval to be used has a much greater influence on the cost of the work than the map scale. As has been stated, the smaller the contour interval, the lower the altitude at which the aerial photographs must be taken. Thus the greater will be the number of pairs of aerial photographs that must be taken and used to cover a given area. Therefore in comparing costs of contour maps, consideration must be given to the contour interval.

In regions of low relief, as along the Atlantic and Gulf coasts where elevations vary but a few feet, the construction of contour maps by means of aerial photographs would be more expensive than by plane-table methods, but the planimetric base can be constructed advantageously by photogrammetric methods and the contours delineated thereon by plane-table methods.

IMPORTANCE OF THE "COMPLETION SURVEY"

In the stereophotogrammetric method it is necessary, after the photogrammetrist has represented on the map those features that he has been able to see in the stereoscopic model, to make what is called a completion survey. This is a field survey whose purpose is to delineate on the map all the information that must appear on it, but which cannot be secured by an office examination of the aerial photographs; and to delete all undesired information that has been indicated on the original drawings by the photogrammetrist. The engineer responsible for such surveys is charged with doing whatever may be needed to perfect the map. His duties briefly are as follows:

(1) To classify all roads; add omitted roads, trails, and houses; and delete all roads, trails, and buildings not appropriate to the



THE OLD AND THE NEW IN PHOTO ALIDADES

Left: Instrument Used in Early Alaskan Work. Right: Instrument Designed by R. M. Wilson of the Survey and Built by the Division of Field Equipment in 1937

map. (2) To delineate all state and county reservations and other important civil division boundaries, as well as section lines. (3) To procure all place names, and verify the spelling of all names to appear on the map. (4) To indicate and accurately locate all important details, including bench marks that may have been omitted. (5) To complete the mapping of those small areas within the body of the map which the photogrammetrist was forced to omit owing to density of shadows, clouds in the photographs, gaps between flights, or defects in the negatives. (6) To check and redraw the map in all places where the delineation is erroneous.

To December 1, 1937, the total area aerially photographed for the Geological Survey was approximately 210,313 sq miles in the United States (including the east half of the Tennessee basin) and approximately 22,000 sq miles in Alaska. The total area compiled in planimetric maps, to which the contours were to be added by ground methods, was approximately 137,021 sq miles in the United States (including the entire area of the Tennessee basin) and approximately 16,315 sq miles in Alaska. The total area having contours delineated on the planimetric base maps was 1,995 sq miles, of which 970 sq miles was by means of the aerocartograph and 985 sq miles by means of the multiplex aeroprojectors (Tennessee basin).

The demonstrated value of these aerial mapping processes indicates strongly that there must be a gradual shift from the methods used in the past to modern photogrammetric procedure. Records clearly indicate that the photogrammetric method will reduce the cost, in all regions except those of very low relief, for a map of the same quality as that procured by the plane-table method. The severe tests for accuracy to which maps made by the new method have been subjected have shown definitely that the contour lines are indicated with remarkable accuracy and that the cultural, drainage, and woodland details are so exactly represented that it is difficult to measure the error that may exist. Another advantage of this new method is that it is essentially an office operation, in contrast to previous methods which have consisted mainly of field work. Therefore, it can be carried on continuously throughout the year.

Mapping with the Multiplex Aeroprojector

By W. S. Higginson

Assistant Topographic Engineer, U. S. Geological Survey, Chattanooga, Tenn.

It is the purpose of this paper to explain briefly the use of the multiplex aeroprojector as employed by the U. S. Geological Survey in mapping the Tennesee Valley. Instruments of this type have been in use by the Survey for about $2^1/_2$ years, and approximately 1,600 sq miles of topographic maps have been completed. The present rate of progress is about 120 sq miles per month when working at a scale of 1:10,000 in country of low relief. Progress in mountainous areas would be much more rapid than this. The work that has been completed to date has been carried on in terrain varying from flat river bottoms to heavily wooded mountainous country where local differences of elevation exceed 3,000 ft. During this period of development the equipment has been improved and recalibrated. This, together with improved technique, has resulted in greater accuracy and ease in mapping.

Before attempting a description of the equipment, it seems advisable to enumerate some of the principles that apply to stereoscopic mapping. (Many of the terms used in the following paragraphs are defined in the Society's Manual No. 15, "Definitions of Surveying Terms.")

1. The horizontal and vertical scales of a stereoscopic model are equal.

2. The cone of light rays utilized in producing the image on the film of the aerial camera must be exactly reproduced by the multiplex projectors.

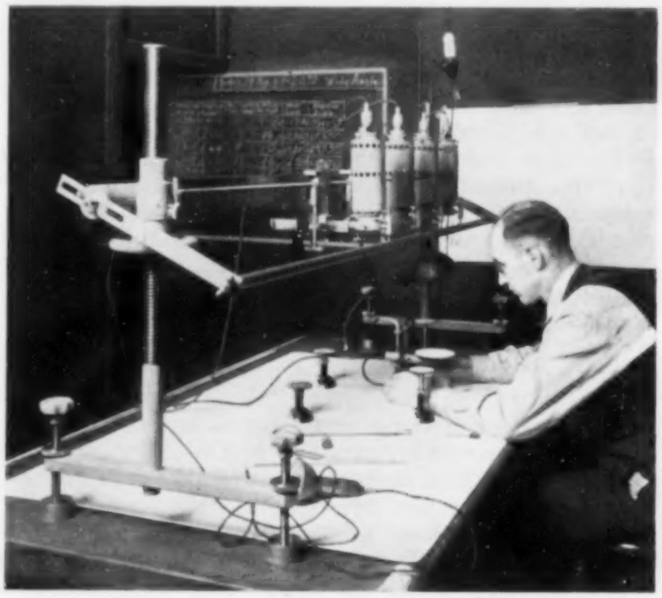
3. The principal point of the diapositive must be adjusted to the axis of the projector lens, and the principal point of the negative must coincide with the axis of the reducing camera lens.

4. The accuracy with which elevations can be measured stereoscopically by the multiplex aeroprojector depends largely on the elevation at which the photographs are made. This value as used by the Geological Survey at present is 600 times the desired contour interval.

5. The longer the air base with respect to the flying height, up to a certain limit, the greater the accuracy with which stereoscopic measurements of elevation can be made.

6. The effect of errors in horizontal position can be minimized by making the original scale of the map much larger than the proposed publication scale.

Mapping with the multiplex aeroprojector requires the use of several instruments, all of which must be properly coordinated in their adjustments in order to secure a map of the desired accuracy. The most important of these instruments are the mapping camera employed in making the aerial negatives, the reducing camera used in making the small positive plates (diapositives), the multiplex projectors with their supporting frame, the tracing table used in the drawing operation, and finally, the special drafting table which supports the multiplex



Multiplex Aeroprojector in Operation

instrument and which serves as a reference plane for vertical measurements.

Unsuccessful efforts of the Survey to utilize existing film negatives, which had not been made with a calibrated camera, emphasized the importance of utilizing a properly designed mapping camera. The distortions introduced by the uncalibrated camera were quickly revealed as distortions in the projected image, which prevented its reconciliation with the established ground control.

The multiplex equipment used by the Survey is of two types. The earlier equipment was designed for use with aerial cameras having a relatively small field of view, while later apparatus was designed to utilize negatives made with cameras having a field of view approximating 90 deg. The so-called wide-angle type has many advantages from the Survey's point of view, but the description in this paper will be confined to the so-called normal type of apparatus.

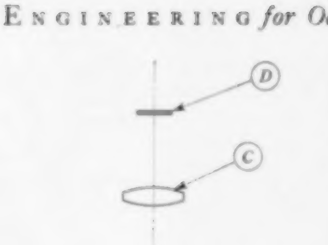


FIG. 1. THE REDUCING CAMERA

The aerial camera employed with the normal type of apparatus should have a focal length of about 210 mm and its focal plane must be perpendicular to the camera axis. The size of the negative must be 7 by 9 in. or, if larger, the excess area must be disregarded in making the diapositive plates as it cannot be accommodated in the small projectors. The focal plane must be equipped with four fiducial marks so located that lines connecting opposite marks will intersect approximately at 90 deg in the principal point of the camera. To obtain the maximum air base length as required by principle No. 5, it is necessary to use the camera so that the 9-in. dimension of the picture is parallel to the flight line. The fiducial marks are utilized to center the negative in the reducing camera and thus bring the principal point of the negative on to the axis of the reducing camera lens.

Use of the aerial camera must be confined to clear, cloudless days, and it is preferable that the photographs be made during the middle of the day when the illumination is greatest and shadows are at a minimum. The pilot of the mapping airplane is provided in advance with a flight map on which has been delineated the lines that must be flown, and naturally he is advised of the altitude at which the flight must be made as well as the desired overlap of the photographs. It is the photographer's duty to manipulate the aerial camera so that the longer axis of the picture is maintained parallel to the flight line, and to make the exposures at such time intervals that the images will overlap in accordance with the specifications. While the most desirable overlap approximates 50 per cent, it is hazardous to attempt to secure overlaps as small as this owing to the effect of ground relief. To avoid this contingency it is usually specified that the overlap shall approximate 60 per cent in the direction of flight.

PREPARATION OF DIAPOSITIVE PLATES

Negatives secured on these flights are used in the reducing camera to project miniature positive copies on glass, which in turn are used in the multiplex projectors. These glass plates are known as diapositive plates and measure 45 by 60 mm each. It is essential that they be coated with various emulsions having a high resolving power. The reducing camera is of the fixed-focus type and its essential parts are shown diagrammatically in Fig. 1. It consists of a glass platform to support the negative (B), a projection lens (C), a platform to support the diapositive plate (D), and of course a light source (A) and reflector. The interrelation of lens, negative, and diapositive must be such that the maximum sharpness of image is obtained in diapositives which will have the precise dimensions needed to fulfill the requirement that after re-projection in the multiplex instrument the cone of rays will be identical with that in the aerial camera. The film negative is registered in position in the reducing camera by making its fiducial marks coincide with corresponding marks on the glass supporting plate, thus complying with principle No. 3. The negative is held in position during the printing operation by a heavy glass pressure plate.

The small diapositive plates are held in contact with the diapositive platform by means of pressure springs. As the exposure is relatively long, it can be adequately timed by means of a light switch with which the instrument is equipped.

It has been previously stated that the interrelation of negative, diapositive, and lens is critical. The relation of the reducing camera to the aerial camera and the multiplex projectors is shown in Fig. 2. That part of the figure indicated by points A, B, C, and D represents the aerial camera and its lens L_1. The section C, D, G, H represents the reducing camera and its lens L_2 utilized in reducing the negative to proper size, while section G, H, E, F represents the cone of rays as projected by the multiplex apparatus though the lens L_3. It will be recalled that principle No. 2 requires angular equality of the cone of rays below the multiplex projectors and the aerial camera. Consequently, the angles AL_1B and EL_3F must be equal. Assuming that the focal length of the aerial camera (f_c), the width of the negative (CD), the principal distance of the projector lens (f_p), and the optimum projection distance (L_3P) are known, it is a simple matter to compute the length GH, which is the required size for the diapositive plate. Knowing the values of GH and CD, as well as the focal length of the reducing camera lens, the proper values can be determined for separations a and b. Experience has shown that the reducing camera must be set with extreme care in order to obtain the dimension for the diapositive which will result in the desired angular equality and yet maintain the maximum sharpness of image.

PROJECTING THE DIAPOSITIVES

The diapositive plates are projected to a table surface on which the drawing is accomplished by means of small optical projectors. Projectors of the normal type, as well as the bar on which they are supported, are described in detail in a paper by Eric Haquinius, M. Am. Soc. C.E., entitled "Air-Mapping the Brazos River Area" (CIVIL ENGINEERING for July 1937). It is necessary to provide a special drawing table on which to support the projector bar. The Geological Survey uses a heavy slate table which has a plane upper surface to represent the reference plane, or sea level, to which all vertical height measurements are referenced. The slate slab is supported by a steel frame with adjustable legs so that the effect of irregularities in the floor may be eliminated and the slate surface brought to a horizontal position. Inasmuch as all vertical measurements are referenced to the slate-top table, it is essential that its

surface be plane within a very small tolerance, and it is believed that irregularities do not exceed 0.003 in.

The small tracing table used in the actual drawing of the map is shown in Fig. 3. Its construction provides a small circular platen (31) on which the images are projected, a vertical metric scale (51) which serves to measure the height of the platen, and a drawing pencil (53) which can be thrown in and out of operation as desired. The platen carries at its center a fine luminous point which is vertically above the tracing pencil. The base of the instrument is provided with three low-friction bearing points which permit it to be moved readily over the drawing surface.

HOW STEREOSCOPIC EFFECT IS OBTAINED

Multiplex projectors make use of the anaglyphic method of projection in order to secure stereoscopic vision. For this reason each lamp house of the projector is equipped with interchangeable red and blue-green filters of complementary colors. The image in one projector is projected through a red filter, while the image of the adjacent projector is given a blue-green color by means of a proper filter. In order to perceive the stereoscopic model, the operator wears spectacles constructed of tinted glass identical with that of the filters. Thus equipped he perceives the image from one projector with one eye, while with the other eye he perceives only the image from the second projector. If the projectors are properly adjusted he will obtain a realistic stereoscopic impression of the landscape.

To understand the use of the multiplex aeroprojector, consideration must be given to the method employed in adjusting the diapositive plates to proper position and the provision made for securing the desired map scale. The scale to be used in any case depends largely on the contour interval and the amount of detail to be represented. When the appropriate scale and contour interval have been determined, a polyconic projection is drawn on map paper at the specified scale and on this is plotted all the horizontal control available. The amount of control depends largely on the accuracy of the map to be constructed. Points sufficiently definite to make good control points include fence intersections, right-angle road intersections, small isolated trees, and the corners of large buildings. For regions where no definite points are available, three points selected on a curving road can be used. In heavily wooded mountainous country it is sometimes necessary to use the intersection of ridge lines.

The map sheet is placed on the multiplex table in such a position that the flight lines will be parallel to the

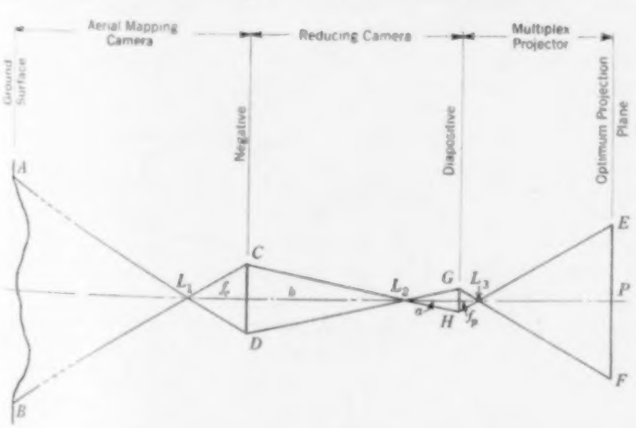
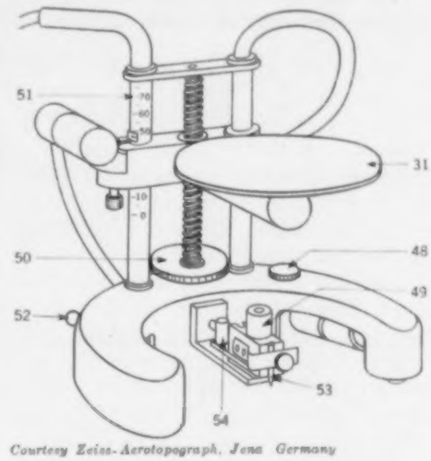


FIG. 2. INTERRELATION OF VARIOUS MULTIPLEX MAPPING INSTRUMENTS

multiplex bar. The small diapositive plates are placed in the projectors and so adjusted that the principal point of the plate will coincide with the axis of the projector lens. It will be recalled that the ray bundles issuing from the projectors are similar to the ray bundles that went to form the original negative. To reproduce the tilt and relative position of the aerial camera at the moment of exposure, it is essential that rays from two or more projectors to a definite object on the ground, such as a road fork, must intersect in a common point (Fig. 4), and that this intersection occur at the proper elevation. In adjusting the multiplex projectors to position it is customary to make use of the elevation of definite objects in the four corners of a model. The procedure followed is such that when properly performed, all rays to these four points will intersect at the elevation of these points as determined by field survey methods. It will be appreciated that the scale of the model can be fixed entirely by the separation that is given to the two projectors along the axis parallel to the supporting bar. An increase in the distance between the projectors will cause the rays to intersect at a greater distance below the projector lens, and therefore the images will be enlarged and the scale correspondingly increased.



Courtesy Zeiss-Aerotopograph, Jena Germany

FIG. 3. THE TRACING TABLE

THE TECHNIQUE OF ADJUSTING THE PROJECTORS

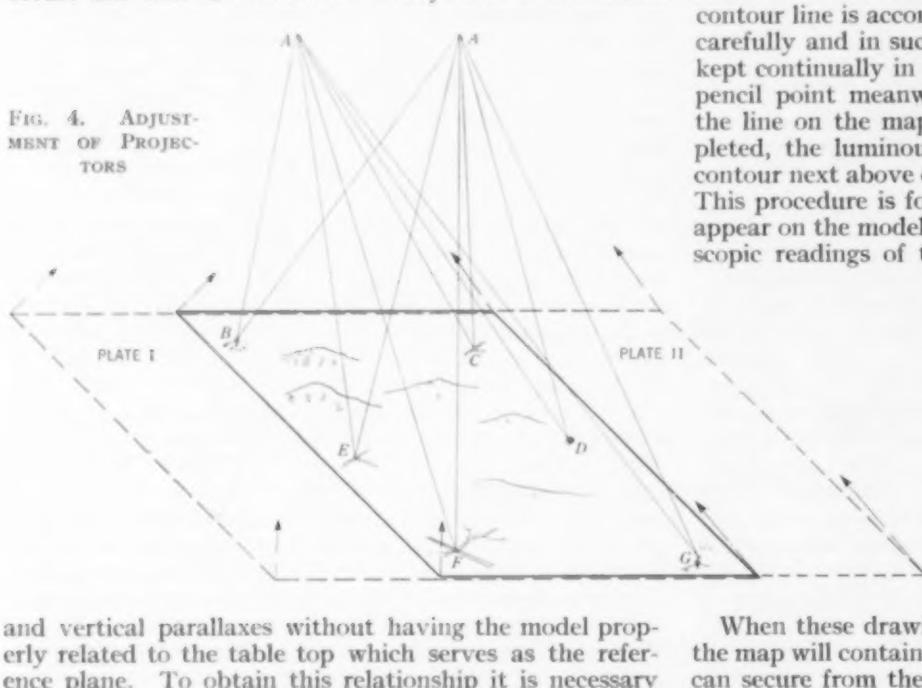
The procedure required to adjust the projectors to their proper positions will be briefly described. Two adjacent projectors are rotated in azimuth and adjusted along the Y axis of the instrument (that is, perpendicular to the supporting bar) until a crude stereoscopic image is obtained that has approximately the scale desired. An examination of such a model will show that the corresponding rays to the control points fail to intersect properly at the determined elevation. When this occurs it is said that "parallax" exists at that point. "Horizontal" parallax is the distance between image points on a line parallel to the X axis of the instrument. It can be increased or diminished by manipulation of the bx movement. "Vertical" parallax is the displacement of the image points in a direction parallel to the Y axis of the instrument. It will be remembered that the image from one projector is in red and the other in green. If the failure to coincide is very large, then two images in red and green will be observed on the platen of the tracing table. When proper intersection is secured these colors will merge at that particular point and result in a white image rather than a colored image, but precise intersections can only be obtained by stereoscopic vision.

The process of eliminating these parallaxes throughout the model cannot be described at length but it may be said that following a more or less regular manipulation of the *by*, *bz*, and *swing* adjustments, the projectors can be tilted and tipped and altered in azimuth until the desired intersections are secured. After the first pair of diapositives are so adjusted, it is possible to add a

third one and so adjust it as to eliminate the parallaxes between it and its adjacent projector. In this case, of course, all adjustments must be made with the third projector.

Further consideration will show that it is possible to secure the desired intersection of rays free of horizontal

FIG. 4. ADJUSTMENT OF PROJECTORS



and vertical parallaxes without having the model properly related to the table top which serves as the reference plane. To obtain this relationship it is necessary to make use of the ground control that has been obtained in the field. By proper adjustments of the foot screws of the instrument, the plastic model can be tipped and tilted in such manner that the selected control points will have the elevations and positions corresponding to those determined in the field.

When the model fits the projection in scale, and the elevations of the control points read the true values, the model is said to be in absolute orientation. Then any contour line on the model will be parallel to the table top and hence can be properly delineated on the map by movement of the tracing table. When the model is properly set up and matched to the map sheet the actual drawing operations can be undertaken.

HOW THE ACTUAL DRAWING IS DONE

It is customary to divide the mapping work into four steps, which are performed in the order named: (1) culture, (2) contours and useful elevations, (3) drainage features, and (4) woodland boundaries.

To draw these features the operator works on the stereoscopic model common to two projectors and when this area has been completed he changes the illumination to include a third projector and at the same time cuts off the light from the first projector, thus working with projectors Nos. 2 and 3. In this manner he is able to complete the map by successive steps.

To draw cultural features such as a highway, the luminous point in the center of the tracing table platen is so adjusted that it apparently is in contact with the road surface. The operator then lowers the pencil point to the drawing paper and moves the luminous point along the road, altering its elevation continually by the proper screw of the tracing table in order to keep the point in contact with the road surface. If this procedure is accomplished with due care, the line that is drawn by the pencil point will be an orthographic projection of the roadway on the map surface.

Contour lines are plotted in a somewhat different manner. In this case the luminous point is set to the elevation of the contour line to be drawn, and the entire tracing table is then moved until the luminous point seems to be in contact with the ground surface as delineated in the stereoscopic model. The drawing of the contour line is accomplished by moving the tracing table carefully and in such manner that the luminous point is kept continually in contact with the ground surface, the pencil point meanwhile delineating all ramifications of the line on the map paper. When one contour is completed, the luminous point is raised or lowered to the contour next above or below, and the process is repeated. This procedure is followed for all the contour lines that appear on the model. It is customary also to take stereoscopic readings of the elevation of all prominent road forks, hilltops, and other points whose elevation might be useful at a later time. These elevations are written in pencil in the proper position on the map surface.

The drawing of drainage and woodland boundaries is similar to the process described for cultural features. It has been found helpful to record woodland boundaries on a separate oversheet to avoid confusing it with the contour lines.

When these drawing operations have been completed, the map will contain all the information that the operator can secure from the stereoscopic model. It remains, of course, for the field forces to make the all-important "completion survey" described by Mr. Pratt in the preceding article. The map is then returned to the office and is ready for the customary inking, editing, and publication steps.

ADVANTAGES OF THE MULTIPLEX METHOD

From the preceding description it will be realized that the multiplex method is far different from that used in the past when the plane table was the most suitable mapping instrument. Several advantages result from this new method. In the first place a steady output can be obtained from the instruments because the operation is carried on in the office where all the delays due to inclement weather conditions are eliminated. Moreover, it is customary to operate on a two-shift per day basis and this of course increases the output per instrument. Because it is impossible to obtain photographs at very great altitudes owing to the limited ceiling of the commercial airplanes, the scales at which the maps are drawn are very much larger than is customary for plane-table work as carried on by the Survey. This avoids congestion of detail in the drawings and makes it possible to ink them at larger scales than usual, the desired publication scale being secured by photographic reduction. It will be appreciated that maps constructed in this manner can be materially enlarged without seriously detracting from their accuracy. This cannot be done with maps published in the past because they are engraved at the publication scale and any enlargement is bound to result in enlarging the engraving errors in the original copy.

The first maps completed by this method were examined very closely to determine their accuracy. This investigation was made by means of third-order transit traverse profiles which were compared with corresponding profiles taken from the multiplex drawings. The results were very favorable to the multiplex method, as regards accuracy of both elevation and horizontal positions.

The Detroit Sewage Treatment Plant

Ultimate Population of 4,000,000 May Be Served by Works Now Nearing Completion

By Clarence W. Hubbell
Member American Society of Civil Engineers
Hubbell, Roth, and Clark, Inc., Consulting Engineers, Detroit, Mich.

The background, development, and a brief general description of Detroit's sewage disposal project were presented by Mr. Hubbell in the July issue of "Civil Engineering." Supplementing that article, the present account provides a more detailed description of the major units of the sewage treatment plant itself. The works here discussed are now under construction and are expected to be completed early in 1939.

Sewage treatment consisting essentially of plain sedimentation, sludge incineration, and chlorination of effluent, was recommended by the consulting engineers on the Detroit sewage disposal project. This degree of treatment was approved by the Michigan State Board of Health and is deemed adequate to meet the present situation both as to local need and treaty obligations.

A general description of the project was given in the July issue of Civil Engineering, and reference is made to Fig. 3 of that article, which shows the areas to be served by the plant and interceptors. The plant itself is advantageously located in an industrial area, about a mile above the mouth of the Rouge River, and is surrounded by developments which tend to discourage the use of nearby property for residential purposes.

The interrelation between various plant units, without reference to their actual location at the site, is shown in Fig. 1, while Fig. 2 shows the general layout of the units under construction. The interceptors bringing sewage to the pumping station are designed and built to serve an ultimate population of 4,000,000 people and have a maximum capacity of 2,000 cu ft per sec. This is equivalent to a flow rate of 1,292 mgd, or a maximum per capita rate of 324 gal, which allows for a liberal quantity of first flush storm-water. The average per capita rate, including normal water supply, manufacturing wastes, and infiltration in the combined sewerage system is estimated at 175 gal per day.

A surge basin is provided for the protection of structures and equipment in the interceptors and plant, and to prevent street flooding through manholes. The basin will hold 14,400 cu ft and is fitted with a long weir to discharge surge water in excess of this amount directly into the outlet conduit, by-passing the plant. Computations indicate that if unrelieved, the maximum surge that might occur would rise 85 ft in a standpipe 40 ft in diameter. (The problem of surge in the Detroit interceptors, and the model studies used in its solution, were described in Civil Engineering for March 1937, in an article by Arthur B. Morrill, M. Am. Soc. C.E., and Harry Kallgren, Assoc. M. Am. Soc. C.E., entitled "Surge in Water and Sewer Tunnels.")

The circular pumping station has an outside diameter of 113 ft and will be equipped with eight motor-driven centrifugal pumps set in the dry at an elevation that will permit them to prime from the open wet well. The average lift is about 30 ft and each pump discharges through a vertical flume over a weir into an individual channel leading to a rack screen located in the screen house. Provision is made in each channel for the overflow and return of sewage to the wet well in case the screen becomes clogged. The rack screens are mechanically raked and the screen bars spaced to give a net opening of 3/4 in. Following the screens, there are eight grit chambers, one for each pump. As a result of model tests, these units are of somewhat unusual design, being 160 ft long by 16 ft deep. The width varies with the capacity of the pump served in order to give an average velocity of about 1 ft per sec in each case. Mechanical equipment is provided for the continuous removal of grit. (See "Grit Chamber Model Tests for Detroit, Mich., Sewage Treatment Project," by George E. Hubbell, Assoc. M. Am. Soc. C.E., in Proceedings, December 1937.)

For a population of 2,400,000 and an average sewage flow of 420 mgd, as of 1950, an average removal of 21 tons of wet screen rakings and 62 cu yd of grit per day is expected. These rates, however, may be exceeded by as much as five times for short periods following a heavy storm or general rain. Provision is made for grinding and incinerating screen rakings, and for incinerating grit.

At the discharge end of the grit chambers, a by-pass connection is provided by which, in case of emergency, sewage at this point can be diverted directly into the plant outlet conduit, either with or without chlorination.

Open aerated channels were considered for conveying sewage from the grit chambers to the sedimentation

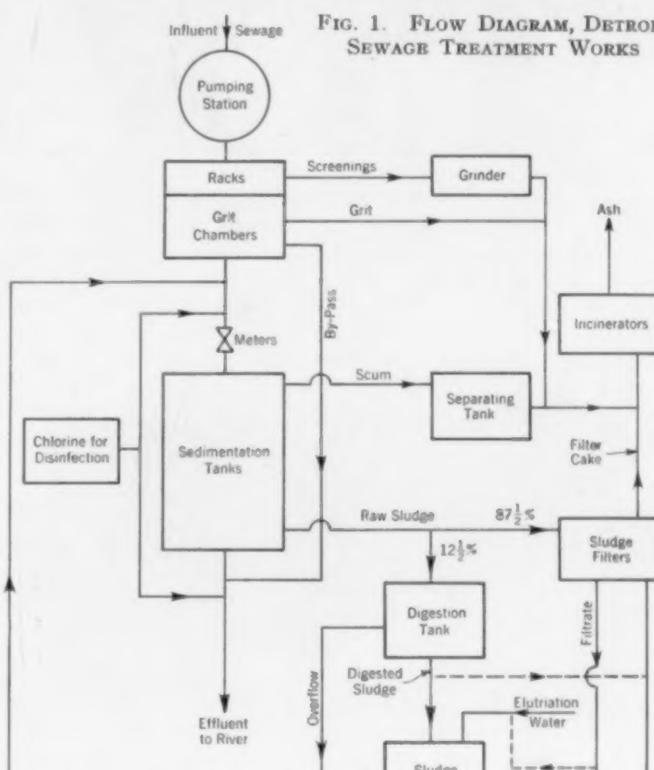
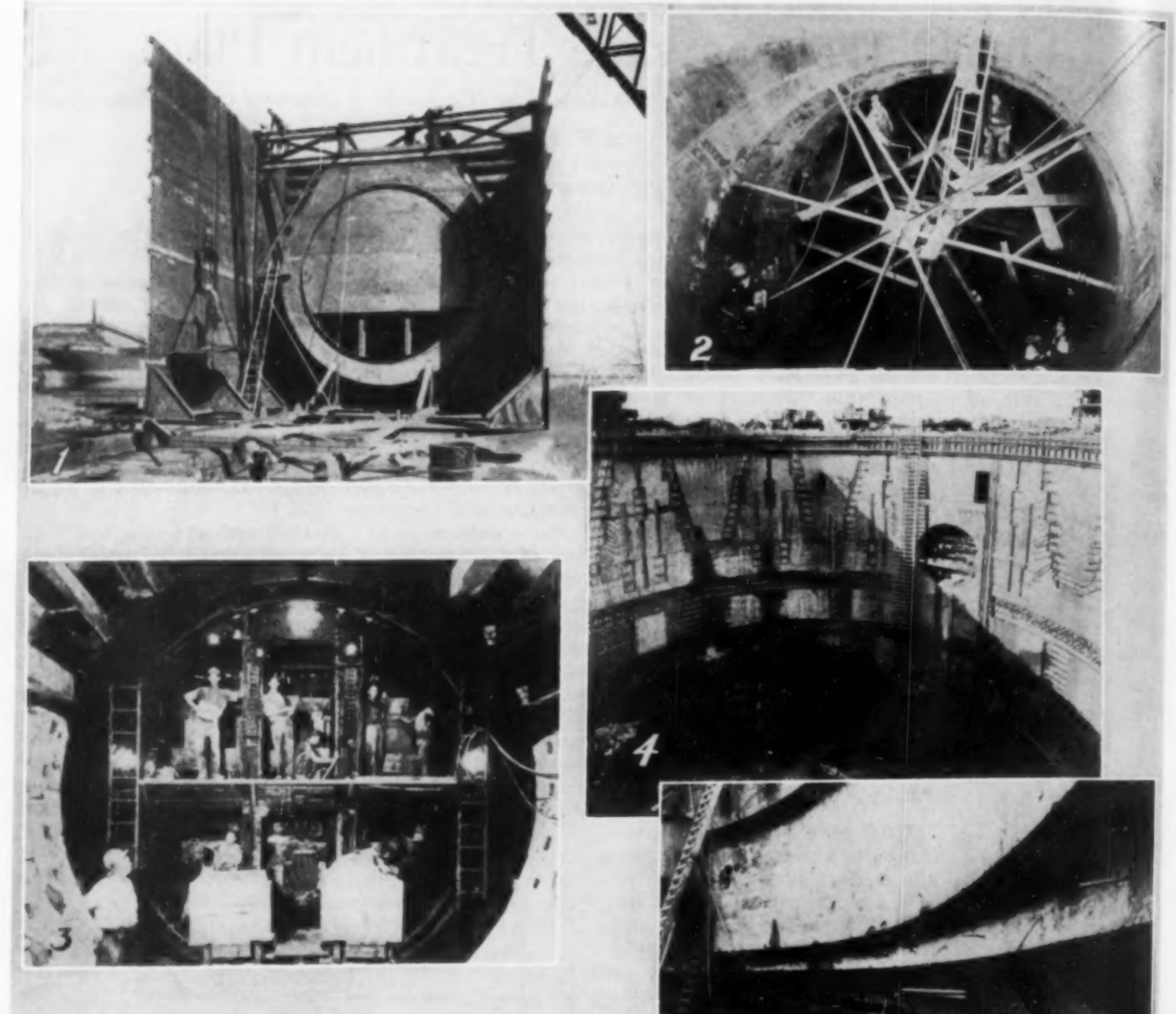


Fig. 1. Flow Diagram, Detroit Sewage Treatment Works



STEPS IN CONSTRUCTION OF DETROIT SEWAGE TREATMENT WORKS

(1) Outlet Conduit Crib During Erection. (2) Interior of Elbow of 18-Ft Diameter Outlet Crib. (3) Outlet Conduit Driving Shield, Showing Precast Concrete Liner Blocks and Hydraulic Jacks. (This Shield, 25 Ft 6 In. in Diameter, Was Driven Through Blue Clay at an Average Rate, Including Shutdowns, of 21 Ft per Day, with a Maximum 24-Hour Drive of 57.7 Ft and a Sustained Monthly Footage of Over 40 Ft per Day.) (4) Interior of 110-Ft Diameter Pumping Station Caisson During Excavation and Sinking. (The Caisson Was Sunk to Rock Through About 85 Ft of Soft Clay.) (5) Cutting Edge of Pumping Station Caisson, with One of the Four Landing Piers Visible at Lower Right. (6) Foundation for Sludge Digester. (7) Sedimentation Tanks, Inlet End.

OUTLET END OF SEDIMENTATION TANKS

tanks, but in the final design a closed conduit was adopted for this purpose, and equal distribution to the tank units is accomplished by an adjustable control system of valves and measuring devices.

The sedimentation tanks are built in units of seven each, and are supported on pile foundations. Each individual tank is 272 ft 8 in. long, 16 ft wide, and about 14 ft deep. They are designed for an average detention period of $1^1/_2$ hours, which is equivalent to a mean velocity of 3 ft per min flowing through the tank. The inlets are of special design developed from model tests. Each tank is equipped with lateral and longitudinal scrapers for conveying the scum and sludge to the scum receiver and sludge sump.

PRESENT INSTALLATION CAN HANDLE 420 MGD

The present installation is for an average flow of 420 mgd as of 1950, and consists of 8 units (56 tanks), which cover a total area of about six acres. This large surface exposure led to the recommendation of covered tanks, for better tank efficiency and odor control under all weather conditions both in summer and in winter.

Selection of the type of roof to be used developed certain difficulties and differences of opinion. High roofs have the operating advantages of open inspection at all times, ease of making minor repairs, and protection to operators during inclement weather. However, in this case considerations of first cost, general appearance, and the seriousness of the ventilation problems involved, resulted in the adoption of low slab, sod-covered roofs.

It is estimated that the average production of sludge in 1950 will be 240 tons of dry solids per day. This estimate is based on data indicating that a removal of 0.2 lb of dry solids per capita per day may be expected.

Under the present plan of operation, raw sludge drawn from the tanks daily will be conditioned with lime and ferric chloride, dewatered by vacuum filters, and then incinerated. The amount of chemicals required for conditioning the total volume of raw sludge is estimated as follows: lime (as CaO) 10 per cent of dry sewage solids, 24.0 tons per day; and ferric chloride (as $FeCl_3$ anhydrous) 3 per cent, 7.2 tons per day.

Twelve vacuum filters of the blow-back scraper type are provided, each with 500 sq ft of effective filtering area.

The quantity of sludge cake to be incinerated is estimated at an average of 922 tons per day. This includes about 36.5 tons of residual from conditioning chemicals, and a moisture content of 70 per cent in the cake. An incinerator capacity of 1,200 tons per day is specified in detail as follows:

Sludge cake at 70 per cent moisture	1,032 tons
Screen rakings at 85 per cent moisture . . .	146 tons
Grit at 35 per cent moisture	22 tons
Total	1,200 tons

Four incinerator units of the circular, multiple-hearth type, having the required capacity, are now under construction. The average production of ash is estimated at approximately 125 tons per day, dry weight, or say 250 tons sluiced.

The incinerator capacity provided is deemed adequate for a population of 2,400,000 on the basis of incinerating raw sludge as at present proposed, or for an ultimate population of 4,000,000 on the basis of incinerating digested sludge. The project originally included eight digestion tanks, each 105 ft in diameter by 42 ft deep, and an elutriation plant, to reduce both the volume of sludge and the requirements for conditioning chemicals prior to dewatering and incineration. However, as funds were low, only one digestion tank and one-eighth of the elutriation plant will be built at this time. The future installation of the remaining seven tanks, together with elutriation, will depend entirely on a financial analysis of the results obtained from this first unit.

Effluent from the sedimentation tanks will be treated with chlorine to destroy pathogenic or disease-producing organisms. For efficient sterilization, it is estimated that an average of 10 ppm of chlorine will be required, which will amount to $17^1/_2$ tons per day for a sewage flow of

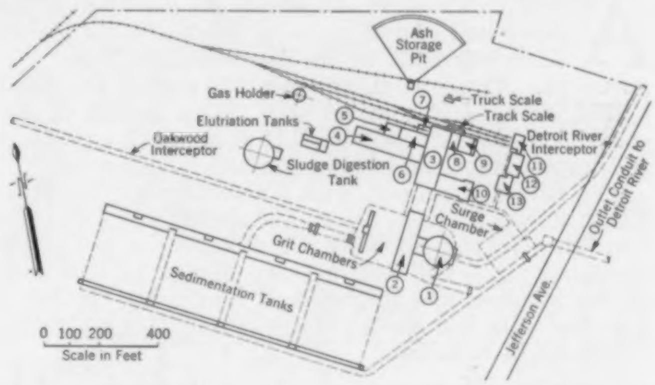


FIG. 2. GENERAL PLAN, DETROIT SEWAGE TREATMENT WORKS

420 million gal. At this rate, and assuming the price of chlorine at $1^3/_4$ cents per lb, the cost of sterilization will be less than 10 cents per capita per year.

The chlorinated effluent is discharged into the Detroit River through a deep earth tunnel 18 ft in diameter and over a mile long, terminating in a submerged crib located some 400 ft beyond the harbor line in swift-flowing water 40 ft deep. The details of the crib design were determined by model tests. The crib lies in the thread of the river which passes through the center of the Trenton channel. The sterilized effluent from the plant thus reaches Lake Erie through this channel, which passes between Grosse Ile and the American shore, and has a normal average flow of 40,000 cu ft per sec, all of which is available for dilution in the lower reach of the river.

Responsibility for all field data required and for final designs, including contract plans, specifications, and estimates, and for all contractual relations prior to and during construction, was assigned to the Detroit City Engineer's office, which was augmented by a temporary staff of engineers and inspectors for the accomplishment of this work.

The revised estimated cost of the entire project as of September 1, 1938, is $22,635,000, of which $19,030,000 is for construction and the remainder for preliminary costs, land, and engineering. The official date set for completion is December 31, 1938. However, an application for six months' extension of time has been filed, upon which decision is now pending. Work progress charts indicate that, as of September 1, 1938, 64 per cent of the construction is completed.

Jacks. (This Shield, 25 Ft 6 In. in Diameter, Was Driven Through Blue Clay at an Average Rate, Including Shutdowns, of 21 Ft per Day, with a Maximum 24-Hour Drive of 57.7 Ft and a Sustained

Soft Clay.) (5) Cutting Edge of Pumping Station Caisson, with One of the Four Landing Piers Visible at Lower Right. (6) Foundation for Sludge Digester. (7) Sedimentation Tanks, Inlet End.

Panoramic View of Sunset Reservoir, with Work in Progress on Both Ground and Roof Slabs

Lining the Sunset Reservoir

By R. B. Rothschild, Jr.

Associate Member American Society of Civil Engineers

Engineer, MacDonald and Kahn Company, Ltd., San Francisco, Calif.

About 26,000 cu yd of concrete are contained in the lining and roof of the new 93,000,000-gal Sunset Reservoir built by the San Francisco Water Department. This concrete represents 13 acres of lining and almost as much suspended slab. The surface of the water in the reservoir will be 31 ft above the floor slab at the deepest point and will have an area of 10.4 acres.

The Sunset Reservoir, with a water-surface elevation 385 ft above city base, can supply almost any district in San Francisco and normally will serve 35 per cent of the community. It will hold a 7-day storage for this area. Water will flow into the reservoir by gravity through a pipe line from San Andreas Lake in San Mateo County, a distance of 15 miles.

Grading and Finishing of Subgrade

Grading for the reservoir involved the removal of 280,000 cu yd of sand from the site and 247,000 cu yd of clay and rock from an adjacent borrow pit; and the placement of the borrowed clay and rock in a rolled-fill embankment along with part of the sand obtained from the excavation. A 2-ft layer of clay was compacted over the area to be lined.

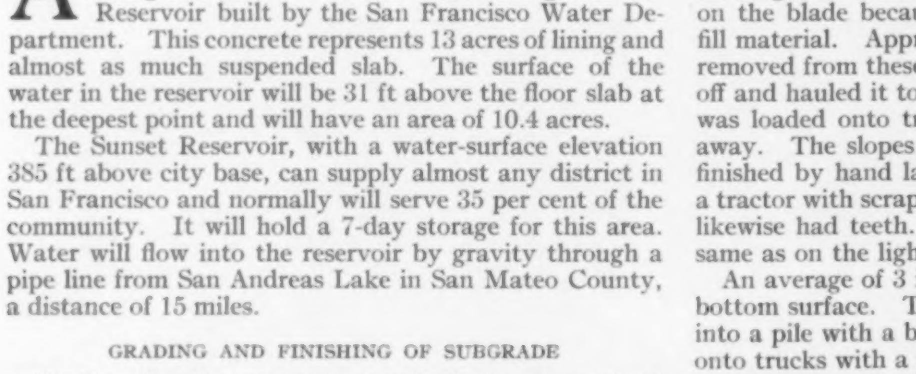
The tractor with scraper, the blade grader, the power roller, and man power all had their place in the finishing of the subgrade. Approximately half of the side slopes—those in filled ground—had a 1-on-3 pitch, and the other half—in natural ground—were sloped 1 on 2. On the 1-on-3 slopes it was found possible to use the blade grader. However, it was necessary to use teeth on the blade because of the hard texture of the rolled fill material. Approximately 5 in. of material had to be removed from these slopes. The grader cut most of this off and hauled it to the bottom of the reservoir, where it was loaded onto trucks by a power shovel and hauled away. The slopes were then sprinkled with water and finished by hand labor. It was found necessary to use a tractor with scraper on the 1-on-2 slopes. This scraper likewise had teeth. The operations were otherwise the same as on the lighter slopes.

An average of 3 in. of material was removed from the bottom surface. This was done by scraping the surplus into a pile with a blade grader and loading this material onto trucks with a power shovel. After the surplus was removed from the bottom, water was applied and a 10-ton roller finished the surface. All footings and other inaccessible places were graded by hand and rolled with a hand roller.

Weather conditions played a most important part in the construction program and the cost of subgrade preparation. Because of the density of the reservoir fill, there was practically no drainage through the ground. As a result, rainy weather would cause a delay of many days and necessitate additional work in completing the subgrade.

In programming the concrete construction, the main problem was to create an economic balance between the size of the concrete pour and the amount of falsework and forms to be provided. Also, the forms and falsework had to be designed so that they could be readily set up and removed.

The slopes and bottom were lined with a 6-in. slab of reinforced concrete. Slopes were poured in alternate panels extending about 50 ft from floor to top of wall. At the center of almost every panel was a column footing, which was poured at the same time. In general, four panels, each containing about 30 cu yd, were poured in a day. Concrete was delivered in trucks, ready mixed, at the



Fine Grading and Ground-Slab Construction

upper rim of the reservoir, and chuted down the slopes. The bottom was also poured in alternate panels and simultaneously with the column footings contained therein. These panels were mainly 25 by 25 ft and contained about 13 cu yd of concrete. Usually 18 of them were poured in a day.

The piers in the center of the panel slabs were of stepped design. They were formed with removable, metal-lined forms supported on four pins placed in the reservoir bottom. Pins were removed about three hours after the slab and footings were poured, and the forms were removed the following day.

Roof Supports Ready for Pans

The purpose of pouring alternate panels was to make the lining impervious by reducing the amount of shrinkage at the construction joints. Every effort was made to obtain a dense and uniform concrete, to which end it was all vibrated. A 4-in. slump was the maximum allowed in any of the concrete lining. After the lining had been cured for several months, the cracks which developed at the contraction joints were blown out and cleaned with chloride of lime solution. Then a grout of waterproof plastic cement was forced into the joints and a seal coat of the same mix, about $^1/_4$ in. thick, was spread over the cracks.

A copper-sealed expansion joint was installed at the junction of the bottom and side slopes.

CONSTRUCTING THE COLUMNS AND ROOF DECK

Circular reinforced columns 30 to 35 ft tall support the concrete roof. Most of these columns are circular in section, from 20 to 24 in. in diameter, and are spaced about 25 ft on centers in both directions. The forms were of the standard removable sheet-metal type and were left in place four days. Concrete was buggied to the columns on runways supported on the deck forms, and poured a few feet at a time alternately in two or three columns.

The roof deck is of pan construction, with $2^1/_2$-in. slab, and 5 by $14^1/_2$-in. joists spaced 30 in. apart. The joists frame into reinforced concrete beams supported on the columns. Falsework for the deck framing consisted of braced shores resting on 1 by 8-in. sills which were placed directly on the completed floor slab. The shores were capped with timbers and on the latter were laid the 5 by 4-in. supports to which the steel-pan joist and slab forms were attached. Main girders and beams were also framed off of the shoring system.

Partially Completed Slope Paving

Specifications required the shores to be left in place for 21 days after the concrete was poured. However, the steel pans and the beam and girder sides were removed after 4 to 6 days.

The deck was poured in alternate panels, a column being at the center of each panel. Reinforcing steel and mesh were carried through the form stops at the edges of all panels. Concrete was buggied from hoppers charged by mixing-trucks at the upper rim of the reservoir. The maximum buggy haul was about 400 ft. Each panel contained about 12 cu yd, and 18 of them were poured in a day.

Vibrators were used in all the deck concrete. The surface of the deck was made smooth with wood floats and sprayed with a liquid curing compound in the same manner as the lining. Several rows of expansion joints filled with an asphalt mastic were provided in two directions in the deck slab. All joints were located between double joists.

The general manager and chief engineer of the San Francisco Water Department is Nelson A. Eckart. The reservoir was designed under the direction of I. E. Flaa, hydraulic engineer, and C. A. Lauenstein, assistant hydraulic engineer. D. J. Fee was structural designer. Construction was under the general supervision of G. W. Pracy, engineer of city distribution, and O. G. Goldman, assistant engineer of city distribution. W. C. Renshaw

Pouring the Roof Slab

was construction engineer, and W. Ryan the resident engineer inspector. All these men are members of the Society.

Rough grading and embankment work was done by Piombo Brothers at a contract price of $195,700. The contract for concrete lining and roof, amounting to $794,000, and including preparation of subgrade and furnishing and placing of materials, was held by MacDonald and Kahn Company, Ltd. On this latter contract, Sheldon A. Modglin was superintendent on the job under the general supervision of B. F. Modglin, vice-president and general manager. The PWA resident engineer was A. P. White.

FINE GRADING AND GROUND-SLAB CONSTRUCTION

ing about 30 cu yd, were poured in a day. Concrete was delivered in trucks, ready mixed, at the

The History of Irrigation in Utah

By O. W. ISRAELSEN, M. AM. SOC. C.E.

PROFESSOR OF IRRIGATION AND DRAINAGE ENGINEERING, UTAH STATE AGRICULTURAL COLLEGE, LOGAN, UTAH

WHEN in 1847 the advance band of Mormon pioneers diverted water from City Creek, near Salt Lake City, to irrigate their planting of potatoes, they initiated among Anglo-Saxon peoples in America the practice of irrigation on a community basis. How this epic beginning grew into Utah's great and expanding agriculture is here related by Mr. Israelsen. This article is abridged from a paper on the program of the Irrigation Division at the 1938 Annual Convention of the Society.

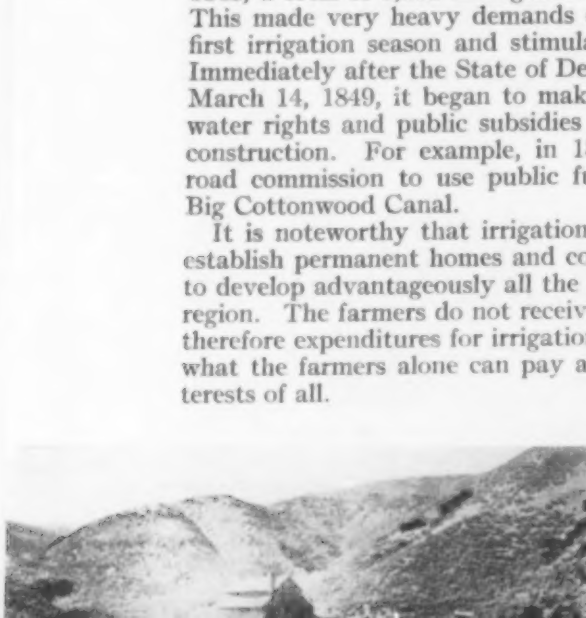
NINETY-ONE years ago, on July 21, 1847, Orson Pratt and Erastus Snow, pathfinders for the first company of Mormon pioneers, entered the valley of Salt Lake and made a preliminary survey of its resources. On July 23 the advance company began to plow, and the same afternoon built a dam to irrigate the soil, which was very dry at the place where they were plowing. The morning of the next day they planted potatoes.

It is customary in Salt Lake valley to plant potatoes in late May or early June in order to produce satisfactory crops. Therefore one wonders about the result of that first planting in July. Concerning this, Whitney says in his *History of Utah*, "While the crops, planted so late, did not mature, yet a few small potatoes from the size of a pea upwards to that of half an inch in diameter were obtained as excellent seed for another year's planting."

The Mormon people had learned the value of cooperation in their struggles for religious freedom, and therefore from the outset cooperative effort became a basic element in Utah irrigation enterprise. It was born of necessity—without it the lives of the pioneers could not have been perpetuated. President Brigham Young saw with remarkable vision the necessity for an adequate and reliable agriculture as a basis for the perpetuity and growth of his people. He saw also that irrigation was to be the foundation of agriculture, and he made a special effort to build irrigation canals, establish irrigated farms, and supervise the control and use of water through church organization and authority.

The first company of Mormon pioneers, under the leadership of Brigham Young, numbered 148, including 3 women and 2 children. A second company of 1,553 persons arrived on September 19, 1847. In October 1848, a total of 1,891 immigrants joined these pioneers. This made very heavy demands on the harvest of the first irrigation season and stimulated activity in 1849. Immediately after the State of Deseret was organized on March 14, 1849, it began to make legislative grants of water rights and public subsidies to expedite irrigation construction. For example, in 1852, it authorized its road commission to use public funds to complete the Big Cottonwood Canal.

It is noteworthy that irrigation makes it possible to establish permanent homes and communities and hence to develop advantageously all the natural resources of a region. The farmers do not receive all the benefits, and therefore expenditures for irrigation systems in excess of what the farmers alone can pay are justified in the interests of all.



Following the public subsidy of 1852, many similar subsidies have been made during the 86 years of irrigation activity in Utah. The most noteworthy ones from private funds were made by the Mormon Church. Their amount cannot be reported with precision, but they have been of great significance in the development of the state. Irrigation construction in Utah has also been subsidized by towns, cities, counties, the state itself, and the United States.

It is noteworthy that the pioneer and territorial period, 1847–1896, was largely a period of building canals—not storage reservoirs. As the pioneers had no power machinery with which to dig their canals and ditches, they relied on their own physical energies supplemented by oxen and horses. Naturally they supplied water first to the most accessible lands. The higher bench lands required longer canals of more difficult construction, which were therefore more costly. The gradual increase in community wealth, together with the urgent need for more irrigated land, provided adequate justification for subsidizing canal construction.

Between 1860 and 1870, the people of Utah built 277 canals having a total length of 1,043 miles. These irrigated an area of 115,000 acres. During this period and the decade following, the diversion weirs for the later canals on each river system were located upstream from the weirs for the earlier ones, thus gradually bringing the higher lands under irrigation.

Each new canal was built by a different irrigation company, thus developing separate management of several parallel canals, all diverting water from the same stream. Competition for water during late-season, low-flow periods was inevitable, and many controversies concerning water rights arose—particularly in dry years. The leaders in water conservation efforts in Utah today are baffled by the tenacity with which the more than 700 separate irrigation companies maintain their identity and nourish the competitive spirit. Consolidation of these companies is one of the most vital steps for water conservation, but progress towards consolidation is surprisingly slow.

The canals built during the early period provided largely for direct diversion of natural stream flow and made comparatively small use of flood flows. But later canals were more and more dependent upon flood waters without storage. The flood flow of most Utah streams occurs during late May and early June, whereas the maximum water requirements for crops are in July and August. Some flood-flow canals justified their cost, but many were disappointing because the flood-flow season is too short to mature crops. Very trying experiences, particularly during dry years and dry cycles, taught Utah irrigators the hazards of relying upon flood flows only, without storage.

From 1860 to 1872 the water level of Great Salt Lake rose about 11 ft; then, during the next 33-year period, it dropped nearly 16 ft. This lowering is believed to be primarily the result of declining precipitation, although diversions from the streams flowing into the lake may

Partially Completed Slope Paving

vice-president and general manager. The PWA resident engineer was A. P. White.

A Good Crop of Celery on Land South of Salt Lake City, Irrigated with Jordan River Water

have had some effect. The 10-year period immediately following Utah's admission as a state (1896) was especially dry, and stimulated great interest in water storage.

During the three decades following 1875 the need for reservoirs was keenly felt, but their construction was retarded by several factors, especially lack of funds. Reservoirs to provide supplemental late-season water for lands under the ditch became the paramount need during the late territorial period. Moreover, the annual water yield of Utah river systems varies widely, the yield in dry years on some rivers being only one-fourth of that in wet years. Thus reservoirs were desired to carry over water from wet years to dry ones. In parts of the State where an occasional dry year or two follows and precedes wet years, carry-over storage is feasible. In other parts, where a cycle of wet years is followed by from 10 to 20 dry years, carry-over storage is not practical.

The state of Utah has invested, from the proceeds of its land-grant funds, more than $2,000,000 in reservoirs and appurtenant works, both in direct construction and in making loans to private companies. The results of these investments have been disappointing. Utah's second cycle of dry years, due to declining precipitation, which began in 1925, has caused serious deficiencies in irrigation water. The depression came after this dry cycle was well under way. These factors, together with others beyond control, contributed to heavy delinquencies and to large losses to the state. The nineteenth biennial report of the State Land Board summarized the state's experience in reclamation as follows:

> Reclamation efforts by the state have proven futile. This is no indictment of the scheme of reclamation in general, but has only proven that the magnitude of the job and the necessity for extensive, unbiased, impersonal investigation prior to the launching of an irrigation project is such that only the federal government is able to handle it.

During the first quarter century of Utah's statehood, various agencies conducted investigations looking towards water storage, including the U. S. Department of the Interior, U. S. Department of Agriculture, and the State Agricultural Experiment Station, either independently or in cooperation with cities, counties, the state, or with irrigation companies. Much valuable engineering data was collected, although coordinated and unified research efforts were lacking.

The 1921 legislature created the Utah Water Storage Commission, and on January 3, 1922, this commission made its first cooperative agreement with the U. S. Bureau of Reclamation, with which it has since cooperated continuously in the investigation of water storage and irrigation possibilities. As a result of these cooperative investigations, a large body of reliable engineering data has been collected. These studies have led to the organization of local irrigation water users' associations, which have made contracts with the U. S. Department of the Interior for the construction of reservoirs, tunnels, siphons, and appurtenant works.

Among the reservoirs thus made possible, the Echo, Hyrum, Moon Lake, and Pineview are completed; and the Deer Creek Reservoir, the largest of all, has been brought to the construction stage. More than 310,000 acre-ft of reservoir water is thus made available annually to supplement the natural stream-flow. The results of the cooperative efforts of the Utah Water Storage Commission and the U. S. Bureau of Reclamation are of extraordinary value to the state.

Operation of Irrigation Systems

The first canals were operated under the direction of the leaders of the Mormon Church. Near the centers of population, however, church leadership was early replaced by town and city control. Later the control and operation of the irrigation systems was gradually relinquished to the water users themselves.

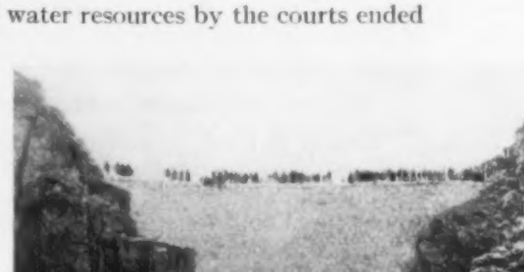
Utah's experience shows that this latter type of operation is the best. The mutual irrigation company—a non-profit organization, usually but not necessarily incorporated—is the dominant form of irrigation enterprise. Irrigators own stock, usually in proportion to the areas of their irrigated land. Expenses of operation are paid from the proceeds of assessments on stock. Nonpayment of assessments results in loss of stock ownership and loss of the right to have water delivered to one's land.

One large Utah irrigation system is operated by a commercial company; several are operated by incorporated water-users' associations, which consist of associated mutual company stockholders; and a few are operated by quasi-public irrigation corporations known as irrigation districts.

Despite the fact that the Mormon leaders were natives of the humid regions of the eastern United States where the doctrine of riparian rights was established by their English ancestors, they saw at the outset that this doctrine was not suited to the needs of the arid West. They evolved the doctrine of appropriation and beneficial use, which asserts that those who are first in time to use water beneficially are first in right. The basic concept of this doctrine is that use of water creates the right and that disuse forfeits or destroys it. Beneficial use is declared to be "the basis, the measure, and the limit of the right."

Beginning in 1852 and continuing for 28 years, the three county selectmen (now commissioners) and the probate judge had control of the water resources in each county. Although designated "county courts" these officials really acted as administrative bodies. These county courts made a few grants of water rights to individuals for power purposes and a large number for irrigation. The good of the community was always considered a dominant element and many restrictions were made to protect the public interest. That the water administration of the county courts was sound and satisfactory is generally conceded by authorities of Utah water laws.

Administration of water resources by the courts ended in 1880 when a new irrigation law was enacted. In this, two basic elements of the law of 1852 were almost entirely eliminated: (1) repre-



the 86 years of irrigation activity

primarily the result of declining precipitation, although diversions from the streams flowing into the lake may

Courtesy L. D. S. Church Historians Office

FROM THIS CREEK THE ADVANCE GROUP OF MORMON PIONEERS FIRST DIVERTED WATER FOR IRRIGATION ON JULY 23, 1847

City Creek, Near Salt Lake City, Utah

BEAR RIVER IRRIGATION PROJECT FLUME OVER MALADE RIVER
Built by Utah's First Large Commercial Irrigation Company Nearly a Half Century Ago

sentation of the territory or the public in all grants and water-right adjudications; and (2) enforcement of beneficial use as the basis of water grants and of perpetuating water rights.

A substantial forward step was taken in 1897, one year after statehood, when the office of state engineer was created. His designated duties included supervising the construction of irrigation works in which the state was interested, maintaining complete records of stream measurements, examining and approving plans and specifications for dams, and supervising their construction. The activity of this office, guided by gradually improved legislation concerning water rights, has been of outstanding benefit to irrigation in Utah. Of the ten state engineers during the 40-year period, the first three devoted their energies largely to improving the chaotic conditions with respect to water rights that developed after the repeal, in 1880, of the laws of 1852.

The first major advancement in irrigation legislation following 1852 was made by the legislature of 1903. Under this law the state engineer collected considerable hydrological data for water-right adjudication, but the law met many obstacles and nothing was accomplished in the actual determination of water rights until after the 1919 law was passed.

As a result of the laws of 1919, since amended and approved, the state engineer's office has functioned effectively in the important but perplexing problem of water-right adjudication. It has made systematic surveys of irrigated lands on several important stream systems, collected data on water requirements, conducted painstaking hydrographic studies, and prepared and published proposed water-right determinations. These proposed determinations have been reviewed by the courts, and with minor modifications, approved and made final. Water-right adjudications under this procedure—which in reality is a cooperative activity of the state engineer and the courts—have cost only a small part of what they would have under the time-consuming methods that prevailed in the courts from 1880 to 1919.

The law of 1919 provided for a revolving fund, seemingly with the intention that state appropriations for water-right determinations should be repaid by the water users. However, the courts have held that the wording of the law did not justify assessments to repay the state funds. This defect was corrected by the 1933 legislature.

MAKING IRRIGATION AGRICULTURE PERMANENT

Farmers in Utah, as elsewhere, were early confronted with two major irrigation problems—first, how to conserve water, and second, how to conserve soils. In 1888, when the Utah Agricultural Experiment Station was created, it set out to develop by scientific research, a body of information on the conservation of these two resources. The results of its own research, together with the results of similar research conducted cooperatively with the U. S. Department of Agriculture, have been presented in a series of 77 experiment station bulletins and circulars, and 61 scientific contributions to technical journals. These results constitute in large measure the basis of the following résumé.

Conservation of water and conservation of soil productivity are both vital to the perpetuation of civilizations in arid regions. Nevertheless, in some cases at least, those practices that are designed to conserve the one do not contribute to the conservation of the other. Recognizing the need of coordinating the two, it is helpful to attempt a résumé of findings with respect to each, as follows:

Water Conservation

1. There is a definite relationship between the amount of water applied to a particular soil and the yield for a given crop. This relationship—designated the yield-water curve—has been experimentally established for a few soils and crops in Utah. It shows that above a certain minimum required to produce a crop, further increments in water produce less and less crop increase until an amount is applied that will produce the maximum yield. Amounts in excess of this cause either a decrease, or no increase in yield, and therefore are a waste of water.

2. Water is used efficiently by plants, and therefore conserved, when the soil-moisture content is so maintained that water is always available. To most plants water is readily available when the moisture content of the soil ranges from a minimum of 2 or 3 per cent above the wilting point up to capillary capacity.

3. Maintenance of a high degree of soil fertility by crop rotation, use of barnyard manure, and other soil amendments contributes to the efficient use of water by plants and thereby to the conservation of water.

4. Well-drained soils constitute valuable irrigation-water reservoirs by virtue of their capacity to hold water in the capillary form. The capacity of the soil reservoir is influenced by the depth of the soil, its texture, and structure.

5. Soil permeabilities are of great importance in the selection of methods and designs for farm irrigation systems.

Soil Conservation

1. In Utah considerable loss of fertile soils due to erosion has occurred either because of improper design, or lack of design, of irrigation distribution systems and drainage channels. The principles of design now understood by engineers, if properly applied, would prevent much soil erosion.

2. Upward flow of water from ground-water sources, with resulting evaporation at the surface and deposition of alkali salts, must be prevented to conserve irrigated soils in arid regions.

3. In some areas, application of water in excess of actual crop needs is essential to leach alkali salts from the soil.

4. In the low-lying areas of many valleys, artificial underdrainage is essential to make downward flow and leaching possible.

5. The alkali control and reclamation problem by artificial drainage in soils of fine texture, compact structure, and low permeability is extremely perplexing. In attacking this problem, the engineer needs the counsel and cooperation of the chemist, agronomist, and soil scientist.

The history of irrigation in Utah shows that many perplexing problems have been met and solved; that the Utah pioneers by cooperating met seemingly insurmountable difficulties; that subsidizing of irrigation enterprises, wisely directed, is desirable and should be encouraged; that public ownership of all water resources, subject to rights to use water for beneficial purposes, is a sound and workable doctrine; that public collection and interpretation of the factual data that are essential for the adjudication of water rights is desirable and workable; and that by scientific irrigation and soils research substantial progress has been made towards placing Utah's agriculture on a sound and permanent basis.

and irrigation possibilities. As a result of these cooperative investigations, a large body of reliable engineering data has been collected. These studies have led to the

1932 were almost entirely eliminated: (1) repre-

Courtesy L. M. Winsor, M. Am. Soc. C.E.

Masonry Dam for Irrigation Reservoir at Enterprise, Utah

Built by the Farmers Themselves at Very Small Money Cost

The Barrier System of Flood Control

Protective Works in Kessler Canyon, Utah, Are Outstanding Example; Rubble-Concrete Masonry Structures Prove Economical and Dependable

By L. M. Winsor

Member American Society of Civil Engineers

District Engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture, Salt Lake City, Utah

To remove the destructive debris from mountain streams, the barrier system of flood control was developed in Utah in the early 1920's. Later the system was extended and applied to the control of torrential floods. Mr. Winsor here outlines the basic principles of design and describes several outstanding applications of the method. Of particular interest is his emphasis on, first, the desirability of increasing the height of barriers—as opposed to building new barriers or digging out debris—as additional capacity becomes necessary; and second, the strength and economy of properly constructed rubble-concrete masonry walls. This article is abridged from Mr. Winsor's paper before the Irrigation Division at the 1938 Annual Convention of the Society.

In the humid East, flood waters have little or no value. For this reason, control works are designed to pass the flow along to the sea with as little damage as possible. In the West the problem is quite different. Water is the very life blood of every Western community, and it is imperative that flood control works be planned to conserve not only the runoff from normal precipitation, but also, as far as practicable, that from torrential floods.

In the West the most damaging floods are composed of mud, sand, and gravel, along with organic matter of all kinds mixed into a thick mortar. Often this mass of debris contains great quantities of boulders. In the northern Utah floods of 1923, 1930, and 1932, many of the larger boulders carried weighed from 20 to 300 tons each. There was but little water in these floods in addition to that required to mix the mud and rocks into a batter having the consistency of thick concrete.

The Kessler Canyon Spillway Is a Bowl-Shaped Structure of Rubble-Concrete Masonry

It Is Now Being Increased in Height to 100 Ft Above the Stream Bed

In many parts of the West, floods have become a real menace because cities, towns, and highly improved farm properties have been extended to the crest of alluvial cones at the mouths of canyons without leaving room for the flood stream to spread and drop its burden of debris. A striking example is found in the city of Los Angeles, where in some cases expensive improvements have been made even within the limits of the stream bed.

It is the debris that the flood stream carries, rather than the water, which causes the most damage; and a method for removing this heavy load has been developed by the Bureau of Agricultural Engineering in cooperation with various agencies in the state of Utah. The ability of a stream to pick up and carry loads of sand, gravel, boulders, and mud varies as the sixth power of the velocity. Conversely, if, by spreading, the stream is retarded to half its former velocity, it will drop $^{63}/_{64}$ths of its load. This accounts for the formation of alluvial cones immediately below the mouths of canyons; and it is the principle that was borrowed from nature in developing the "barrier system" of flood control.

Debris Left by a Typical Mud Flow

For the barrier system to be successful, a few simple rules must be followed. First in importance is the selection of the site. The barrier should be placed where the stream can spread to several times its normal width. It is more important to choose a site where the barrier basin will provide ample room for the flood stream to spread than one where the barrier can be constructed cheaply.

The barrier may be built of materials brought down by erosion, and may be raised from time to time as the need for additional storage arises. It is placed directly across the stream bed and extends to high ground on each side. A spillway is built in a position where it collects the flood waters after they have been relieved of their burden of heavy debris and returns the flow to the natural channel.

A stilling pool immediately above the spillway is essential to catch the sand and silt that is carried partly in suspension in a flood stream. It need not be large. The heavier debris and much of the fine materials are deposited on the surface of the cone that forms above the stilling pool.

Provision must be made for raising the barrier, including the spillway, as the need arises. The period in which this will become necessary varies with the frequency and intensity of the floods and the size and slope of the basin above the barrier.

The first control works of this type were built at Nephi, Utah, in 1922. They consisted of two barriers of earth, with spillways of juniper posts and rock. One was located in the canyon from which the main gravel flow issued, and one a short distance above the intake to an

with two major irrigation problems—first, how to conserve water, and second, how to conserve soils. In 1888, when the Utah Agricultural Experiment Station was

and that by scientific irrigation and soils research substantial progress has been made towards placing Utah's agriculture on a sound and permanent basis.

A RUBBLE CHECK DAM THAT FAILED BECAUSE OF IMPROPER CONSTRUCTION

The Only Concrete Used in It Was Placed on the Exterior, as Pointing Material

irrigation canal. Both were placed in positions where the stream could spread over a considerable area before being collected and returned through a spillway to the natural channel. The two structures cost only 60 per cent as much as the annual expense had previously been for cleaning gravel from canal and ditches. The experiment was a complete success, and the original works are still in good condition after 16 years of operation. There was no expense for maintenance during the first 10 years. At the end of that time a third small barrier was built at the intake to the canal to catch gravel washed into the channel by side streams coming in below the first barrier.

In 1923 and immediately thereafter, the system was extended to some 25 streams in Utah and surrounding states. In each case the works have been successful, to the extent that there is no longer any doubt as to the adaptability of the barrier system of flood control to a wide variety of conditions, and particularly to mountain streams in the arid West.

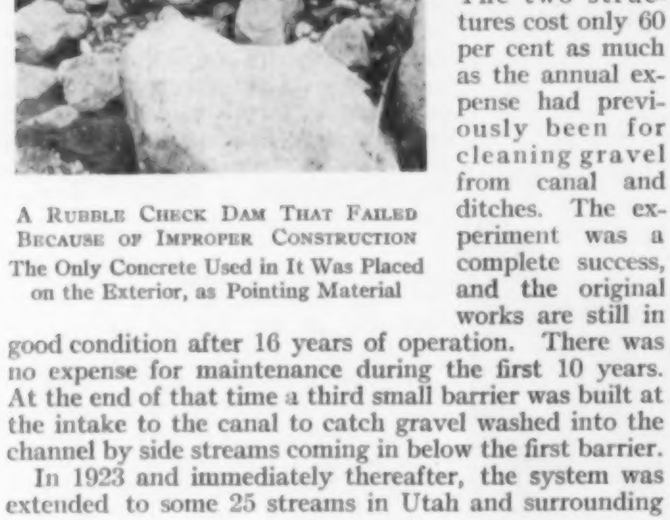
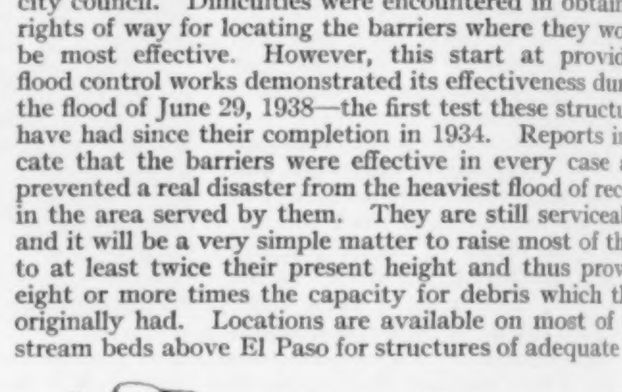


FIG. 1. PLAN AND SECTIONAL ELEVATION OF KESSLER CANYON FLOOD BARRIER

The first of the experimental barriers has never been increased in height. Some have been raised once and others twice. When additional capacity is required, it is usually more effective and more economical to raise the original barrier than to build a new one at a new location. By doubling the height of the barrier and spillway, it is usually possible to increase the storage capacity to eight or more times the original.

In working out the flood control program undertaken at Los Angeles some two years ago, the barrier system in a modified form was applied to a limited extent. "Debris basins" were built at the mouths of some of the canyons along the foothills above Glendale. The spillways of these debris basins were only 8 or 10 ft above the stream bed, and no provision was made for carrying them up to levels where they might become fully effective. The plan of control calls for digging out and removing the debris after each flood instead of raising the barriers to greater heights. If the material removed were placed on the barrier embankments, and the spillways were raised in proportion, these basins would soon have a capacity several times greater than is now provided.

In 1933 the foundation structures for a series of barriers at El Paso, Tex., were designed and built at or near the mouths of canyons along the steep slopes immediately above the northeast portion of the city. A limit of 20 ft in height was placed by the city engineer through the city council. Difficulties were encountered in obtaining rights of way for locating the barriers where they would be most effective. However, this start at providing flood control works demonstrated its effectiveness during the flood of June 29, 1938—the first test these structures have had since their completion in 1934. Reports indicate that the barriers were effective in every case and prevented a real disaster from the heaviest flood of record in the area served by them. They are still serviceable, and it will be a very simple matter to raise most of them to at least twice their present height and thus provide eight or more times the capacity for debris which they originally had. Locations are available on most of the stream beds above El Paso for structures of adequate ca-



SKETCH SHOWING A TYPICAL APPLICATION OF THE BARRIER SYSTEM OF FLOOD CONTROL

Debris Left by a Typical Mud Flow

with spillways of juniper posts and rock. One was located in the canyon from which the main gravel flow issued, and one a short distance above the intake to an

pacity to meet requirements over a long period of years.

The earlier flood control works in Utah were designed primarily to remove gravel from streams so that the water could be used for irrigation without the expense of removing the gravel from the canals. Later the barrier system was extended and applied to the control of torrential floods. It has met with unquestioned success and has proved to be the only means known for handling economically some of the more difficult floods in mountain streams. The most outstanding example of control works of this character is at Kessler Canyon, near Garfield, Utah, 22 miles west of Salt Lake City, where engineers of the American Smelting and Refining Company had previously tried out various methods, including a series of 22 substantial check dams, in an effort to save from disaster the Garfield smelter, located directly at the mouth of the canyon. On June 14, 1927 an unprecedented flood destroyed practically all of the control works that had been built, and severely damaged a considerable part of the plant. The only check dam that remained intact was one of rubble and concrete masonry.

A Flood Control Structure on Santa Clara Creek, Utah
The Spillway Crest Is 125 Ft in Length and 32 Ft Above the Stream Bed

THE WORKS AT KESSLER CANYON

In their efforts to protect an investment of ten million dollars and an industry which employs over eleven hundred men, the officers of the smelting company requested advice from the writer, who prepared a plan of control that was subsequently built. Some features of the plan were accepted with reluctance by the engineers who represented the Western division of the organization. The principal objection was raised over the proposal to build a barrier a mile long across the mouth of Kessler Canyon, with a rubble-masonry spillway 60 ft high and resting on an alluvial foundation where bedrock is at least 1,000 ft below the surface.

Construction was started in August 1927. Five minor floods, each one large enough to carry heavy deposits of gravel and boulders, flowed over the works while construction was in progress but no particular damage was done, the deposits were checked as fast as they came, and the floods served an excellent purpose in backfilling, puddling, and testing the more important structures.

A second heavy flood in 1929 and another in 1930 gave the barrier the most severe kind of test and served to demonstrate the stability of the structures and their effectiveness in protecting the smelter. Then, in July 1937, the heaviest flood of record brought a flow estimated by the plant engineer at 15,000 cu ft per sec Maintenance work on the barrier had been neglected following 1930 and the basin above the barrier had filled to crest level. Because of this, a considerable amount of heavy debris was carried over the spillway. Great quantities of boulders, some of them weighing three to five tons, were dropped over the spillway crest into the channel below, where an emergency debris screen of reinforced concrete caught them and prevented clogging of the conduit through the plant.

Proper Construction of a Rubble-Concrete Masonry Retaining Wall
The Principles and Methods That Make for Durability Are Described in the Text

The main barrier (Fig. 1) is now being raised to a height 100 ft above the stream bed, and the complete program mapped out in 1927 is being finished by erecting a primary barrier across the canyon at a suitable location upstream, having an elevation near the upper level of prehistoric Lake Bonneville, where there is opportunity for the flood flow to spread over a considerable area. The expense, while heavy, is considered as only a reasonable insurance against disaster. Incidentally, the engineers who were concerned in 1927 as to the adequacy of the structures and their ability to withstand the terrific action of torrential floods are now ardent advocates of the barrier system of control and of the rubble masonry type of construction for spillways and for channel protection. Kessler Canyon is probably the leading flood-control laboratory for testing the barrier system and the special type of rubble-concrete masonry that has been developed as an integral part of it.

In this particular method of construction, the boulders brought down by floods are recovered and used in building spillways and other control works. The most common and probably the most stable of the spillway structures is bowl-shaped in form. It is built like a huge butter bowl with one side cut out and with wing walls attached upstream and down. The crest is curved in plan and is built in an ogee, with a secondary crest downstream to provide a water cushion.

The first of the experimental barriers has never been increased in height. Some have been raised once and others twice. When additional capacity is required, it is usually more effective and more economical to raise

SKETCH SHOWING A TYPICAL APPLICATION OF THE BARRIER SYSTEM OF FLOOD CONTROL

The principle of the bowl shape is that an arch type of structure is more likely to resist destruction by excessive floods than is one built in angular form. It is also considered to be more economical than the gravity type.

PROPER METHOD OF CONSTRUCTING RUBBLE-CONCRETE MASONRY

Rubble-concrete masonry has been found to be the most satisfactory and the most economical type of construction for flood control works in the West. In building the crest and wing walls of spillways, care is exercised to place the boulders close together in the outer face or faces of the wall, with the thicker end to the outside, and to point the long axis inward and downward. No small boulders and no chinks to level up the wall are used. The interior of the wall and all spaces around the inner ends of each boulder are filled with concrete of first-class grade rather than with sand and cement mortar, which usually develops but very little strength. Large boulders are crowded into the larger spaces on the interior of the wall after concrete has been spaded in, and before the outer edges are raised to new levels.

IN CONSTRUCTING RUBBLE-CONCRETE MASONRY PAVEMENT, BOULDERS ARE PLACED WITH THICK END UP AND LONG AXIS POINTING DOWNWARD

Concrete Is Spread Over Surface of Ground in Advance of Paving and Is Spaded Between Boulders After They Are Placed

This type of construction has produced walls that have more strength than is accredited to rubble masonry by the engineering profession. At Kessler Canyon and elsewhere wing walls and retaining walls with a thickness of 3 ft or less at the base have been built to heights of over 30 ft and have been backfilled with puddled detritus without the slightest indication of failure. One such wall, 34 ft high, 3 ft thick, and vertical, was backfilled by dragline with freshly deposited mud from a flood flow. The hydraulic shock produced by dropping the puddled material into place behind the wall should have caused failure according to all the rules of good engineering practice, but the wall still stands, and careful examination fails to reveal any crack or movement out of line.

THIS 300-TON BOULDER WAS CARRIED OUT OF DAVIS CREEK CANYON, IN UTAH, BY A 1932 FLOOD

The method used in this type of rubble masonry construction is so economical and has such a wide range of application that it is urgently recommended to the profession for serious consideration in the building of retaining walls, check dams, spillways, and lining for floodways. In the very best type of work, only $1^1/_4$ bags of portland cement are used per cubic yard of rubble masonry. If more than enough concrete is used to fill the voids between boulders, the wall seems to be weakened in proportion. It has greatest strength when boulders are placed face to face in the outer surface of the wall, and where they also rest close together on the inside, with only the voids filled with concrete. This is quite contrary to accepted practice, but its worth has been proved in the numerous flood control works where the severest kind of tests have been made.

In the recent floods at Los Angeles and vicinity, many rubble masonry structures failed. So general was the failure that this type of construction has been condemned by the engineers who are designing the flood control works now being planned, and it is reported that they have decided to resort to reinforced concrete for future construction. However, the writer has personally observed that the rubble-masonry check dams that failed were built in such a manner that all the cement and sand mortar used was in the downstream face on the outside of the wall, or had been used for pointing the outer face after the wall was laid up dry. The inner part of the walls observed contained no concrete and was filled with small boulders which were not even bound together with mortar. Some rubble dams in the region that had been built for stability rather than for looks withstood the action of the most severe floods.

There is an urgent need for worth-while projects for the enormous works program recently authorized by Congress, and the barrier system of flood control affords an especially desirable type of work project because of its practicability, economy of materials, and adaptability for common labor. It is recommended that the barrier system, with the rubble-concrete masonry type of structure described here, be given careful consideration by engineers in planning for future flood control works wherever local conditions make its use practicable.

CONSTRUCTION DETAIL OF OVERFLOW SPILLWAY LEADING INTO MAIN FLOOD CHANNEL ABOVE GARFIELD SMELTER

Two-Man Boulders Are the Largest Used

A Decade of Progress in Air Transportation

With Special Reference to Improvements in Planes, Schedule Performance, and Safety

By S. R. Newman

District Traffic Manager, United Air Lines, Salt Lake City, Utah

From a once-a-day run between New York and Washington in 1918 to a daily schedule of 18 coast-to-coast flights in 1938—thus may be epitomized the progress of air transportation in the United States since the War. Particularly in the second decade of that period, developments have followed one another with astonishing rapidity. In fact, says Mr. Newman, air travel may soon become "the most regular and efficient of any known form of transportation." His present article, reviewing the last ten years of air transport history, was on the program of the Society's 1938 Annual Convention at Salt Lake City.

To understand the progress of air transportation in the past ten years, we must first recall briefly a few events of the preceding decade. At the end of 1918—the year of the Armistice—the only scheduled air transportation was a run between New York and Washington. Only one ship operated each way daily over this route. The same was true of the second route, inaugurated in 1919, between Cleveland and New York. Only a few bags of mail were carried on each trip. Rebuilt war-time DH-4's and Curtiss H's, which had to land every few hundred miles for fuel, were used. Motors were unreliable. The pioneer pilots had only a scant number of instruments and no radio equipment.

As a group, the early air-mail pilots were the most experienced flyers in the world, but they averaged between 200 and 300 hours of flying per man. All flying was done by contact—that is when the pilot can see the ground. All weather reports were sent by telegraph, and these were often several hours old before handed to the pilot for analysis.

Airports—if they could be called that—were either pastures or reclaimed park property. Despite almost insurmountable obstacles, the U. S. Air Mail was extended from coast to coast in 1920. Coast-to-coast flying in the early 1920's was done only in daylight. Mail was transported by train overnight. The next morning a new pilot would take the air mail from the train and continue with it. The coast-to-coast air-rail combination took 78 hours, only 12 hours less than through train schedules.

In 1921 a thrifty Congress decided air mail was a costly experiment and made no appropriation for service that year. To prove to the Congress that air mail was necessary and practical and that it could be flown at night as well as by day, a group of mail pilots volunteered to make a continuous day-and-night trip from coast to coast. No facilities had been set up for night flying, and navigation was accomplished by the aid of bonfires lighted along the way by farmers and chambers of commerce. This flight—now a historic one in aviation development—was made on February 22 and 23, 1921. The coast-to-coast time was 33 hours and 20 minutes—less than half the air-rail time. Congress then made a large appropriation for air mail and for provisions to install aids to night flying. The next few years saw vast improvements in motors, landing fields, airplanes, instruments, and lighting facilities.

In 1926 the Post Office Department felt that its pioneering work had been completed and decided to turn the operation of its routes over to private enterprise. The Boeing Air Transport Company and National Air Transport, which later became integral parts of the present United Air Lines system, were successful bidders on the coast-to-coast route. The personnel of the air-mail service—almost to a man—was absorbed by these two companies. When private operations were inaugurated, the flight equipment of the early air-mail days gave way to Boeing 40-B's, the first ships to be designed expressly for air-mail passenger-express service. Cruising at 110 miles an hour, these ships carried a pilot, two passengers, and 1,500 lb of mail and cargo.

Two years later, United Air Lines ordered a fleet of tri-motored 12-passenger biplanes. This design—known as the Boeing 80—inspired a larger design, the 80-A, which carried 18 passengers and provided through service from California to Chicago. Meanwhile, the Ford Company produced a 12-passenger tri-motored all-metal plane which was placed in service between New York and Chicago. On February 1, 1929, the Department of Commerce finished work on the Salt Lake City–San Francisco night lighting of the coast-to-coast airway.

Left: The Last Word in Air Transport, 1926—A Boeing 40-B, the First Ship Designed Expressly for Mail-Passenger-Express Service. Right: The Boeing 80, a Tri-Motored 12-Passenger Biplane of 1928

In addition to the regular landing fields on the route from New York to San Francisco, there were 111 intermediate fields lighted for night landings, and 232 revolving beacons.

By 1930 passenger service was developing. In 1931 United put into service the forerunner of today's modern

THE FORD TRI-MOTORED ALL-METAL PLANE, ANOTHER DEVELOPMENT OF 1928

low-winged transport. This ship was the single-engine Monomail, the first all-metal transport to have retractable landing gear. The Monomail's speed and pay load inspired engineers to design a 3-mile-a-minute, ten-passenger, low-wing monoplane.

18-HOUR COAST-TO-COAST SCHEDULES IN 1933

It was in 1933 that the 3-mile-a-minute Boeing 247 made its debut on United's coast-to-coast air route. Eight hours was cut off transcontinental schedules, and 18-hour coast-to-coast schedules were inaugurated. The "247" was the most talked-of airplane of its period. In 1934 new refinements were made in it; new power plants increased its speed 19 miles an hour, and coast-to-coast schedules were cut to $16^1/_2$ hours.

The next step, in 1936, was when United purchased a fleet of Douglas-built Mainliners—12-ton, 200-mile-an-hour ships—and coast-to-coast time was again cut, to $15^1/_3$ hours. The large air lines put de-luxe 21-passenger club types on the shorter hauls. The 14-passenger Skylounge, with its comfortable swivel chairs and steam-heated cabins, was used on the longer flights such as those between New York and Chicago, and Salt Lake City and San Francisco—non-stop. Three lines offered overnight coast-to-coast sleeper plane service.

Air lines recognize that all forms of transportation—ground, water, or air—are subject to occasional delay. Therefore, air lines do not attempt 100 per cent performance nor do they attempt to start or complete all schedules, preferring to cancel or terminate flights if there is an element of doubt as to weather, which is the major problem they have to face. United Air Lines, for instance, guarantees its pilots $650 a month irrespective of the number of trips started or completed, thus rewarding the pilot for judgment in not flying as well as for the completion of trips. This guaranteed salary is further evidence of a "safety-first" policy. Planes are not permitted to take off when severe icing conditions are known to exist, or bad area belts that would offer any hazard. Planes carry sufficient reserve fuel to fly practically twice the longest non-stop trip. Mainliners have a cruising range of 1,500 miles, and as the bad-weather belt is rarely over 400 miles in width, their long cruising range provides a new safety factor.

A FLYING TECHNICAL LABORATORY; OTHER RESEARCH

For the past year, United Air Lines has had a flying technical laboratory, flying in all kinds of weather, at all altitudes, day and night, testing new equipment and improving the old. A vast improvement in de-icing equipment and almost complete suppression of static have been a few of the amazing developments made recently. This of course adds considerably to the already high safety factor.

Duplication of important instruments has furthered safety and improved schedule efficiency. With two-way radio sets, two motors (either capable of taking a ship off fully loaded and climbing to 10,000 ft), full feathering propellers, and skilled, capable pilots, the industry is progressing in the right direction.

During the past two years, United has developed an instrument radio landing system with which experiments have been conducted at Oakland, Calif. To date its ships and pilots have actually made hundreds of experimental blind landings with this device. This system, which uses an ultra-high-frequency curved landing beam, depends for its effectiveness on the mechanical or automatic robot pilot to regulate all surface controls during the landing maneuver, while the human pilot concentrates on the indicating instruments and makes minor adjustments on the control knobs of the automatic pilot to correct deviation from the horizontal or lateral path of flight. This system, developed in cooperation with an equipment manufacturer, will most certainly be a part of future air-line operation and will become indispensable.

The keystone of United's operation program is its "rule of three," which governs the movement of every airplane on the entire system at all times. The "rule of three" sets forth in order of importance the factors of safety, passenger comfort, and schedule performance, as those that control the dispatch and flying of planes. In

THE BOEING 247-D MADE POSSIBLE A $16^1/_2$-HOUR COAST-TO-COAST SCHEDULE IN 1934

EXPRESS SERVICE. RIGHT: THE BOEING 80, A TRI-MOTORED 12-PASSENGER BIPLANE OF 1928

679

A DOUGLAS-BUILT MAINLINER—15 1/2 HOURS FROM COAST TO COAST

every phase of operation, safety is always the prime consideration; after that has been definitely satisfied, the point of passenger comfort is considered. Secondary to both is the factor of schedule performance.

Planes being flown on instruments—that is when visibility is restricted—must maintain prescribed altitudes, at least a half mile above the terrain, to clear the highest point within a total airway width of 50 to 100 miles. This is substantially a higher margin than required by federal regulation. As an example, between Cheyenne, Wyo., and Salt Lake City, Utah, the prescribed altitudes on instruments are 13,000 ft eastbound, and 14,000 ft westbound, clearing the highest terrain on the radio course by 3,500 ft.

As a check on the maintenance of these new minimum flight altitudes, United has installed flight analyzers on all its planes. This is an automatic recording device which continuously charts altitudes maintained by planes in flight. It also records rates of climb and descent, number of radio contacts, and other pertinent facts. At the completion of each trip the analyzer chart is removed from the sealed barograph and its record scanned. This provides a positive check on the maintenance of the prescribed flight levels for each portion of the company's coast-to-coast and border-to-border routes.

FLIGHT PLANNING AND DISPATCHING

Flight planning and dispatching is supervised by flight executives who are veteran pilots of long experience, and by meteorological and dispatch officials. All captains and first officers are required to appear at the dispatch office more than an hour before scheduled departure. They must make a careful analysis of weather conditions along the course they are to fly, basing their findings on U. S. Weather Bureau maps, forecasts, and teletyped weather reports from observing stations, which are located every 50 miles on the route as well as at strategic off-line points. In the meantime the dispatcher makes an independent weather analysis. Then the two reports are compared. If pilot and dispatcher agree that the weather is flyable with complete safety, then the captain and first officer prepare their plan of flight, giving altitude, estimated speed, anticipated weather, time of arrival, and so forth. No flight is approved for dispatch that cannot conform entirely with company regulations.

To insure precision instrument flying, all pilots are trained and checked periodically on machines which actually simulate a plane in full flight in "blind" conditions. A special recording device, supervised by a flight officer, charts the entire path of the instrument flight and immediately records any faulty pilot technique.

The astounding strides made by air transport in recent years are shown in the following tabulation:

In 1927, it took 35 hours to travel from coast to coast. In 1932, this time was reduced to 27 hours, and today it takes only 15 1/2 hours to span the continent.

The air lines could offer only six round trips between Chicago and New York in 1932. This is one of the most heavily traveled routes in the world. Today there are 23 round trips per day between the two cities—a departure practically every hour of the day. There are 18 coast-to-coast flights daily.

In 1928, the air-line fare was approximately 11 cents per mile. Today it is 5 1/2 cents per mile. In 1940, large air lines will introduce four-motored planes for overland travel, carrying as many as 40 passengers on long flights. Economies will again be effected, and it is hoped that air fares can be reduced without hampering the financial structure of the industry.

In 1927 only a few thousand persons were carried by the air lines of the nation, and last year this figure had leaped to 1,200,000 passengers. In 1932 the air lines hauled 4,679 tons of air mail and 517 tons of air express; in 1937, 11,000 tons of mail and 3,564 tons of express.

MAIL SUBSIDY VIRTUALLY ELIMINATED

In 1932, the United States paid the contracting air lines approximately $20,000,000, and in 1937 this was cut to approximately $14,000,000. Meanwhile, in 1932, purchasers of air-mail stamps paid the Post Office Department $6,000,000 in postage, and in 1937, $12,450,000. In other words, subsidy has been virtually eliminated from the air-mail service. The average income per dollar shows that passengers and express represent 64 cents, and air-mail carried, 36 cents.

When the air-line dollar is paid out, salaries account for 36 cents; fuel and oil, 12 cents; materials, 7 cents; depreciation, 15 cents; insurance, 7 cents; advertising, 6 cents; rental, 4 cents; taxes, 3 cents; and miscellaneous items, 10 cents.

A comparison of today's air-line operation with that of a decade ago presents a forceful contrast, reflecting the rapid progress that has been achieved in flight equipment and navigational aids. The new developments just reviewed, along with other aids that are being perfected daily, will remove susceptibility to weather delays to such a degree that air travel will soon become the most regular and efficient of any known form of transportation.

Erecting the Hawkesbury Bridge, 1887-1889

Reminiscences of a Thrilling Construction Job in Australia

By E. K. Morse

Member American Society of Civil Engineers
Consulting Engineer, Pittsburgh, Pa.

Fifty-one years ago, Mr. Morse went to Australia to erect the bridge that formed the last link in the continuous all-rail connection between the principal cities of that continent. There, at the age of 30, and entrusted with one of the outstanding engineering projects of the day, he was confronted with one stupendous construction puzzle after another. A series of near disasters was averted—some of them by quick thinking and level-headedness, and one by the sheer good fortune of a sudden wind storm. Mr. Morse here tells his own story of this engineering adventure, and readers who visit the Engineering Societies Library will be interested to know that his scrapbook and two large volumes of photographs on the same subject are available there for inspection.

In November 1884, the government of New South Wales, Australia, invited bridge builders throughout the world to send plans and tenders for building a double-track steel railway bridge across the Hawkesbury River, some thirty miles north of Sydney. This resulted in bids from firms in the United States, Canada, Belgium, France, England, Scotland, and Australia, and the plans were referred to a commission of three eminent English engineers for study.

On January 25, 1886, John Whitton, engineer-in-chief for railways for New South Wales, filed his report on 15 designs submitted, concluding his report as follows: "I therefore recommend the acceptance of the tender No. 1 of the Union Bridge Company, the amount being £327,000, subject to the preparation and approval of full detailed drawings and a proper specification of the whole work connected with this bridge." The approved plans called for seven Pratt truss spans of 416 ft each, center to center of piers, with caisson pier foundations. Some of the latter were to extend 185 ft below high water—deeper than any previously attempted.

The Union Bridge Company sublet the sinking of the six caissons to Anderson and Barr of New York City and the masonry work to Saul Samuel of Sydney. Messrs. Arrol Brothers, Glasgow, Scotland, fabricated all the riveted work of the superstructure. All tension members were made in the Union Bridge Company shops at Athens, Pa.—though the steel was rolled in England, shipped to Athens, and the finished members reshipped to Glasgow.

Erection of the superstructure complete was let to S. V. Ryland under condition that he would select a partner competent to complete the erection in case of his death. The Union Bridge Company approved of the selection of the writer, and the firm of Ryland and Morse, contractors, was established in December 1886. A complete plant of hoist engines and erection tools was shipped from New York City to Sydney at once, and Ryland and I with our families and one foreman, Joe Ridgeway, left Chicago for San Francisco on March 1. We arrived in Sydney April 7, 1887.

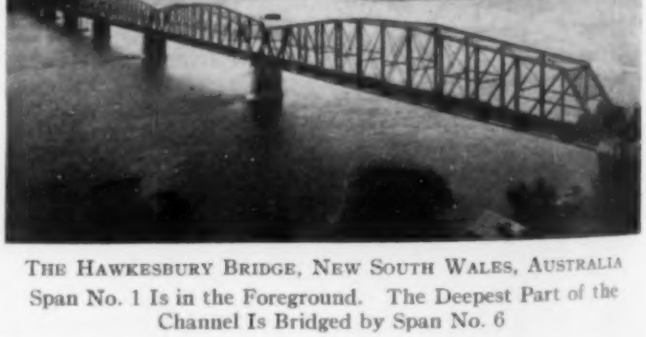
An inspection of the bridge location was very disappointing. There was no yard room on either shore of the Hawkesbury River or along the railroad, and no steamboat landing. The tide amounted to 8½ ft, and the river was subject to dangerous floods and bad tropical wind storms. Worst of all, there was 40 ft of water in the channel and from 40 to 60 ft of soft mud in the river bed—too deep to think of using pile trestle in erecting the spans, as we had planned. Our whole scheme of erection had to be abandoned.

A mile below the bridge site was Dangar Island, which Mr. Anderson of Anderson-Barr had leased as headquarters for his plant and for the offices of the Union Bridge Company. It was obvious that the spans would have to be erected at the island and floated an average distance of 5,000 ft to the piers. Such a thing had never been done—and there we were, thousands of miles from home, with the problem on our hands and no marine experience. Mr. Ryland was sixty years old and had made a record in bridge erection. I was thirty years old and had a record to make. Mr. Ryland decided he would look after the finances and social functions and that I should design the plant and erect the spans.

My only professional equipment, in addition to schooling, was four years as a laborer-mechanic in the Morse Bridge shops at Youngstown, Ohio, three years as a draughtsman in the bridge company's offices, and limited field experience. To overcome my youthful appearance I grew a full beard.

The big problem was the design and location of one or more pontoons to float the 1,000-ton spans, which were 416 ft in extreme length, 60 ft high, and 40 ft wide. Because of a 60-ft overhang at the west abutment, a two-pontoon plan was abandoned and a single pontoon was built. It was 335 ft long, 61 ft wide, and 10 ft deep, and contained 44 water-tight compartments equipped with valves that allowed the tides to flow in and out freely while a span was under construction.

After considerable trouble in launching, the pontoon was floated around the island and scuttled on a pile-capped gridiron deck 2 ft below low water. A 40-ft trestle was then erected on the pontoon, and an extension of the trestle was constructed on a permanent deck so that



The Hawkesbury Bridge, New South Wales, Australia
Span No. 1 Is in the Foreground. The Deepest Part of the Channel Is Bridged by Span No. 6

In 1927, it took 35 hours to travel from coast to coast.

a degree that air travel will soon become the most regular and efficient of any known form of transportation.

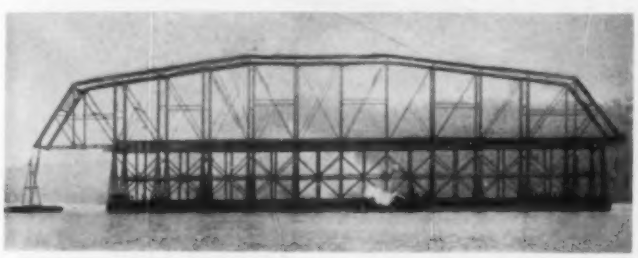
the hoisting engines and traveler could be moved off the pontoon during floating of the spans. This equipment, together with two barges, two residences, office, tool houses, social hall, and rows of houses, was designed, material ordered from Sydney, and completed in six months. Fortunately I was a speedy, tireless designer and draughtsman, but I was indebted to Oscar Schultz, resident engineer of the Union Bridge Company, for much needed advice. Most of the plans were made nights, as I was on construction all day.

During this rush, steel was arriving from Glasgow at Port Jackson, Sydney, to be towed up to Anderson and Barr's dock on Dangar Island. But no stevedore in Sydney would handle the heavy end posts and top-chord sections, so I had to personally supervise unloading all the steel for the seven spans.

Waiting for High Tide

The Pontoon Is Resting on a "Gridiron Deck"; at the Extreme Left the Traveler Used in Erecting the Span Has Been Run Onto a Stationary Trestle

The first span was erected and ready for launching before two connecting piers were completed by the subcontractors. The plan for floating the pontoon from the gridiron to the piers was to stretch a 6-in. coir (Ki-i) rope cable from a pier to the upstream end of the pontoon, and through the pontoon hoist engine (over a 6-ft drum), to a hoist engine at the end of the dock. At low tide the valves were closed, and as soon as the pontoon floated, the slack was taken up at the hoist engine on the dock. Then the pontoon was floated out into the channel and towed upstream by winding the cable around the drum. The coir rope cable was supposed to float, but unfortunately sank to the bottom of the river. After months of waiting, we floated the first span (No. 4) on May 15, 1888, and landed it on the shores of Piers 3 and 4 without a hitch. Then we opened the valves and waited for low tide to float the pontoon clear of the span.



In Midstream, en Route to the Piers with a 416-Ft Span

But the pontoon didn't clear. Mr. Ryland took charge of the pontoon and I took 14 picked men, 7 placed on each pier, with block and tackle, hydraulic jacks, and erection tools, ready for any emergency. The two camber blocks at each pin had been bolted together, but fortunately were not bolted to the trestle. It took only a few minutes to place the jacks, throw down the 22 sets of camber blocks, and release the pontoon.

The next span that was floated was No. 1, on July 12, 1888. The cable was laid from the abutment around the upper end of the island and through the pontoon to the engine at the end of the dock. There was a mild wind blowing downstream, which we ignored, but it proved sufficient to drag the cable so that we barely escaped grounding on the island. The cable then lifted up from the shallow back-channel and the wind drifted the pontoon ashore on the rocks, just below the abutment, where it held fast.

A "Southerly Buster" to the Rescue

It was then high tide. All the men were taken off the pontoon and Ryland and I expected to see our pontoon crushed and the span lost. The tide began to fall and the pontoon and trestle groaned. Just as we had abandoned all hopes, a "Southerly Buster" wind blew a gale upstream and held back the low tide by 2 ft. Our pontoon survived. An examination showed sharp pointed rocks sticking through the bottom of the pontoon in several places, but not under any of the trestle bents. (Later, when the trestle was dismantled, we found that some of the timbers in the bents near where the rocks penetrated the pontoon had crushed $1^1/_2$ in. into the bottom sills. An awfully close call!) At daylight the next morning the span was pulled off the rocks and safely landed at high tide.

Span No. 3 was started on its way in a dead calm early on August 16, 1888, but had gotten only half way to the bridge when a sudden tropical wind storm caused a lurch of the pontoon and snapped the coir rope cable at the wharf. Four large ship anchors were quickly dropped from the four corners of the pontoon, but were of little use in the soft mud. The cable attached to the pier held the pontoon parallel to the river channel while the wind blew the pontoon to the right bank within about 150 ft of rocks on the shore, before the anchors held. Even then, the two anchor chains under the pontoon were so taut they began to cut through the bottom of the pontoon until heavy timbers were worked into place to prevent it. Next morning the anchors were lifted, the pontoon floated to the bridge site, and the span landed in less than two hours.

Thirty-pound wind pressure was assumed for the cable stress; it should have been doubled. It was doubled for the four pontoon anchors, but in every case where the anchors were dropped the action in drifting was like a ratchet, in that one end would drive ahead and hold, while the other end would drift ahead, the two always alternating and never pulling together evenly.

LANDING A SPAN

Spans No. 2, 7, and 5 were placed without incident. Then, at 6:30 a.m. on March 1, 1889, the last span (No. 6) was floated to the end of the dock and started rapidly and majestically for the closing gap. The morning was so still and quiet that Union Jack and Stars and Stripes gave not a flutter in response to the cheers and whistles as the pontoon left the gridiron.

THE LAST SPAN RUNS WILD

The pontoon had reached pier No. 6, and had run out and tied up three additional hausers, besides the coir cable, as an added precaution, when, without a moment's warning, it was struck by a gale that snapped the three hausers like threads and parted the cable between the pontoon and the dock. The four anchors were immediately dropped—but not in time to prevent the pontoon from swinging clear around and heading, straight end on, for pier No. 6, on which I was located with some ten splendid erectors and a foreman. A dangerous accident was inevitable—yet not a man ran out on span No. 7 for his life, and no man dared jump into the shark-infested river.

The crash came, and immediately the 65-ft overhanging end of the floating span headed for span No. 7. Fortunately this end of the span on the pontoon was riding somewhat higher than the other—just enough so that its upstream shoe barely passed over the bottom chord eyebars of No. 7, midway of the first panel, and came to rest with the end posts just touching each other. The heavy track ties that had been clamped to the track stringers of span No. 7 cushioned the blow, but there was still enough shock left to cut in two a 32-in. stringer.

When the two spans locked, the one on the pontoon lurched downstream so that it appeared to be sliding off the trestle. The timbers in the trestle groaned. Instantly every one of us grabbed jacks and tackle and in less than half an hour the shoe of No. 6 span was clear of No. 7. In the meantime Ryland and his men with my crew on pier No. 5 had pulled the other end of the span up to pier No. 5, and within one hour from the time the treacherous gust of wind struck, the last span was landed safely.

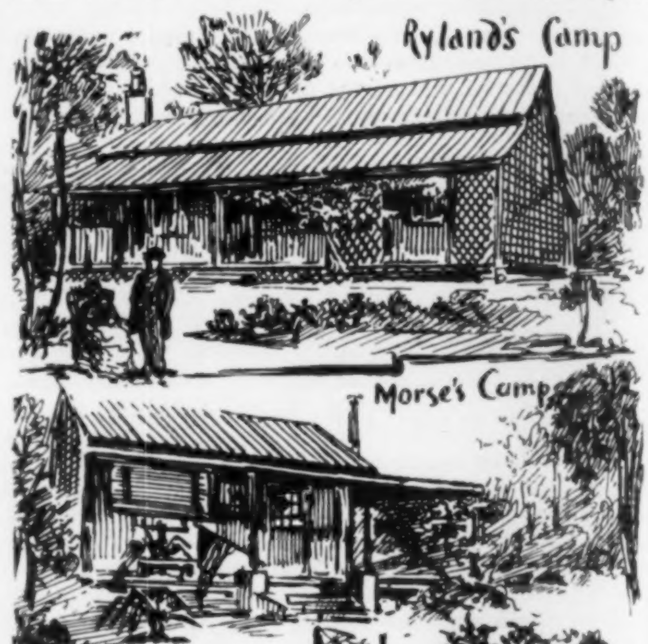
What was it that prevented a costly wreck of property and consequent loss of life? Without question, the strength of the trestle structure. It was of Oregon pine, and the smallest timber in it was a 12 by 12. Every post in every bent was on a batter, and every bent had braces (12 by 12) from the top sill to the bottom sill of the next bent. Every connection was bolted by 1-in. bolts, and every sill was bolted to the pontoon frame. Twice this sturdy trestle saved us from disaster.

Tropical storms were frequent; one registered $6^3/_8$ in. of rainfall in one hour. Before the pontoon was dismantled a rainfall of 21 in. in four days brought a disastrous flood down the Hawkesbury River that swept the pontoon down the river into the Pacific Ocean, a complete wreck.

HOW THE MISTAKES MIGHT HAVE BEEN AVOIDED

We made a number of mistakes on the Hawkesbury Bridge, and most of them should be charged to me. I think it is worth while, in concluding this story, to point out how they might have been avoided:

1. We should have stretched a wire rope from the dock to each abutment and practiced floating the pontoon and trestle, thereby settling the question of fouling the cable.



SKETCHES FROM THE SYDNEY TRIBUNE OF JUNE 15, 1888

2. During the months of waiting for completed piers, the effect of wind on the pontoon and trestle should have been tested by trial trips.
3. The scuttled buoyancy of the pontoon and trestle should have been tested by actual trials at the bridge site before attempting to land a span.
4. Accurate contour soundings of the river bed should have been obtained, or made if not obtainable.
5. The anchor chains should have been longer.
6. The fact that the great bend in the Hawkesbury River land-locked Dangar Island should have been properly appreciated. As a matter of fact, it was ignored.

ENGINEERS' NOTEBOOK

This department, designed to contain ingenious suggestions and practical data from engineers both young and old, should prove helpful in the solution of many troublesome problems. Reprints of the complete department, $8^1/_2$ by 11 in., suitable for binding in loose-leaf style, are available each month at 15 cents a copy.

Analysis of the Positive Surge in a Rectangular Open Channel

By E. H. TAYLOR, JUN. AM. SOC. C.E.

INSTRUCTOR, DEPARTMENT OF MECHANICAL ENGINEERING, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIF.

THE hydraulic jump has held the interest of engineers for a considerable length of time. Observations upon this interesting phenomenon agree extremely well with the theory and, perhaps for this reason, it has been widely discussed in the technical literature. Little has been written, however, on the positive surge, which is closely related to the jump. The equations for the surge, or traveling hydraulic jump, have been stated by Boris A. Bakhmeteff in his *Hydraulics of Open Channels*, and by others. While nothing new in principle is presented in the following remarks, the method of representation is

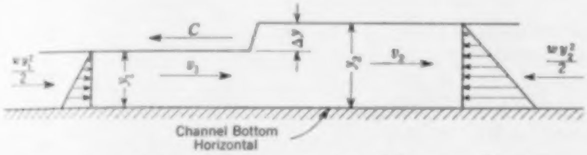


FIG. 1. NOMENCLATURE FOR THE POSITIVE SURGE

believed to be of interest. Further, confirming data are given, of which there is a paucity at the present time.

The fully developed surge may be thought of as a traveling hydraulic jump, or, conversely, the jump may be treated as a fully developed surge for which the absolute wave velocity is zero. Consider (Fig. 1) an initially steady flow without friction, characterized by a velocity v_1 and a depth y_1. Let the flow be suddenly retarded downstream so that the velocity will finally become v_2. This results in the piling up of the flow into a surge, the front of which moves upstream with a velocity C.

Relative to axes moving with surge velocity C, the time rate of change of momentum per unit width is $\frac{w}{g}y_1(v_1 + C)(v_2 - v_1)$, or, $\frac{w}{g}y_1(v_1 + C)\Delta v$. This is equal to the difference in hydrostatic force per unit width, which is $\frac{w}{2}(y_1^2 - y_2^2)$, or $\frac{w}{2}[y_1^2 - (y_1 + \Delta y)^2]$. Equating and simplifying:

$$(\Delta y)^2 + 2y_1\Delta y = -\frac{2}{g}y_1(v_1 + C)\Delta v \quad \ldots\ldots [1]$$

If the term Δy is small in comparison with y_1, this equation becomes, as Δy approaches zero,

$$dy = -\frac{v_1 + C}{g}dv \quad \ldots\ldots [2]$$

The equation of continuity is $v_1y_1 = v_2y_2 + C\Delta y$, and if Δy approaches zero this becomes

$$dy = -\frac{y_1}{v_1 + C}dv \quad \ldots\ldots\ldots\ldots [3]$$

Combining Eqs. 2 and 3,

$$C = \sqrt{gy_1} - v_1 \quad \ldots\ldots\ldots\ldots [4]$$

which is the velocity of a wave of small amplitude relative to fixed boundaries.

Integration of Eqs. 2 and 3 will not give the proper relation between y and v, since the assumption on which they are based breaks down when finite values of Δy are considered. Equation 4 shows that the upper layers of a surge, moving in deeper water, travel faster and evidently overtake each succeeding layer. The surge then finally has a tumbling motion, which is characterized by a fairly definite and enduring front. When this is the case, Eq. 4 is not true and any relation based on it evidently will also be false. It is necessary to go back to Eq. 1 and solve for Δy:

$$\Delta y = -y_1 \pm \sqrt{y_1^2 - \frac{2}{g}(v_1 + C)\Delta v}$$

Now, $y_2 = y_1 + \Delta y$ and $\Delta v = v_2 - v_1$ so that

$$y_2^2 = y_1^2 - \frac{2}{g}y_1(v_1 + C)(v_2 - v_1) \quad \ldots\ldots\ldots [5]$$

From continuity, $C = (v_1y_1 - v_2y_2)/(y_2 - y_1)$, and inserting this expression for C in Eq. 5,

$$y_2^2 = y_1^2 - \frac{2}{g}\left(v_1 + \frac{v_1y_1 - v_2y_2}{y_2 - y_1}\right)(v_2 - v_1) \quad \ldots [6]$$

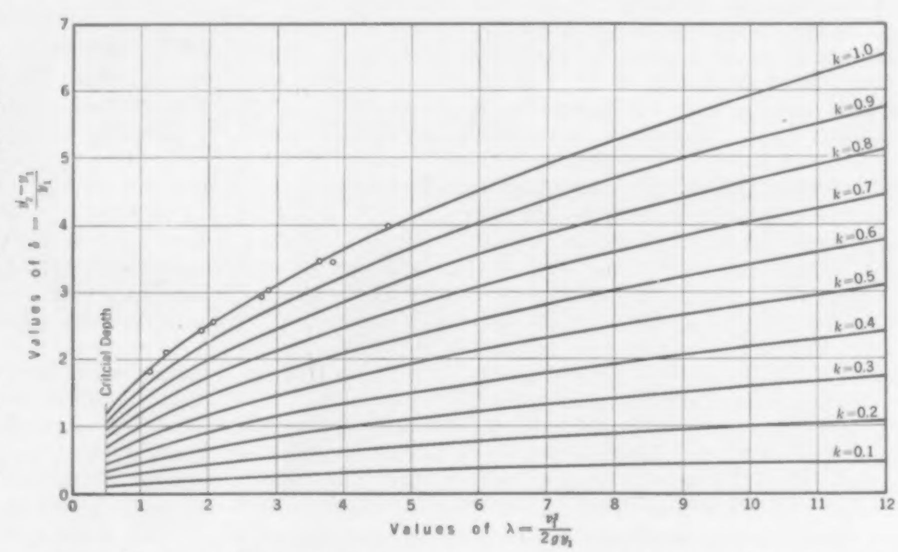


FIG. 2. GENERAL EQUATION (DIMENSIONLESS) FOR POSITIVE SURGE IN RECTANGULAR CHANNELS; INITIAL DEPTHS BELOW CRITICAL

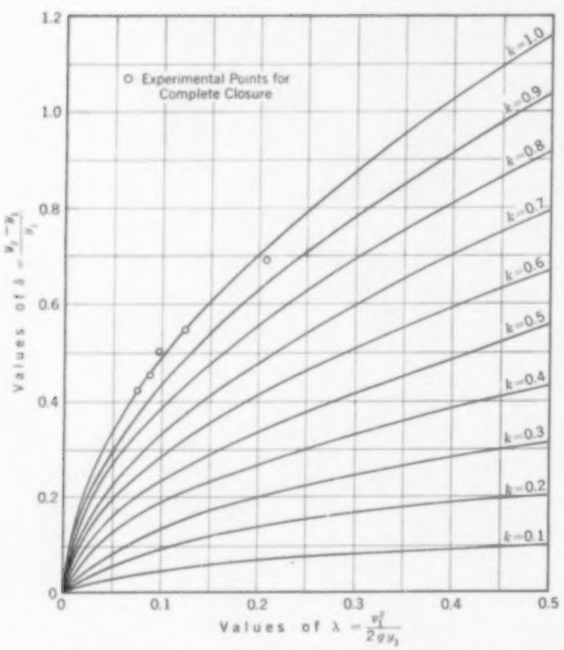


FIG. 3. GENERAL EQUATION (DIMENSIONLESS) FOR POSITIVE SURGE IN RECTANGULAR CHANNELS; INITIAL DEPTHS ABOVE CRITICAL

It is noted that the final depth of surge y_2 depends upon the initial depth y_1, the initial velocity v_1, and the final velocity v_2. The last will ordinarily depend upon downstream conditions. The retardation in velocity will be represented by the factor k, so that the final velocity is given by $v_2 = (1 - k)v_1$. Introducing the dimensionless quantities $\delta = \frac{y_2 - y_1}{y_1}$ and $\lambda = \frac{v_1^2}{2gy_1}$ into Eq. 6, and simplifying,

$$\frac{\delta^3 - 2\delta^2}{\delta + 1} = 4k^2\lambda \ldots\ldots\ldots\ldots [7]$$

Figures 2 and 3 are graphical representations of Eq. 7. Plotted thereon are experimentally determined points for complete stoppage of flow corresponding to $k = 1.0$. The curves of Fig. 4 are crossplots from Figs. 2 and 3, giving δ as a function of k for fixed values of λ. The experimental points were obtained at the hydraulic laboratory of the University of California.

The equation of the hydraulic jump is obtained by making C equal zero or $v_1y_1 = v_2y_2$. The factor k may then be written $(1 - y_1/y_2)$. Equation 7 is modified for this case:

$$\delta^2 + 3\delta + 2 = 4\lambda \ldots\ldots\ldots\ldots [8]$$

Equation 8 may be verified as being identical with the more familiar form of the hydraulic-jump formula. It is noted that for $\lambda < 1/2$ (initial flow at a depth greater than critical) the roots of Eq. 8 are negative. This agrees with what is already known—that is, that the initial flow must be below the critical depth in order that the jump equation may have a physical significance.

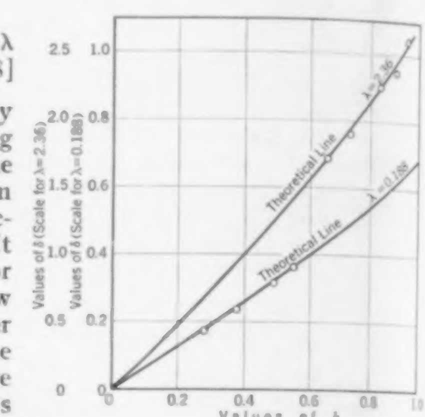


FIG. 4. HEIGHT OF SURGE AS FUNCTION OF FLOW RETARDATION (INITIAL CONDITIONS FIXED)

Photoelastic Analysis of Vierendeel Trusses

By MAX M. FROCHT

ASSOCIATE PROFESSOR OF MECHANICS, CARNEGIE INSTITUTE OF TECHNOLOGY, PITTSBURGH, PA.

assisted by M. M. LEVEN

MECHANICIAN, PHOTOELASTIC LABORATORY, CARNEGIE INSTITUTE OF TECHNOLOGY

THERE is a tendency in modern steel and concrete design to turn to structures of the statically indeterminate type, and great progress has been made in the methods of analyzing them. The Cross method of moment distribution, for example, has eliminated much tedious work. However, even this method loses much of its simplicity in complex structures, especially when the elements cannot be treated as straight bars.

Civil engineering projects are costly, and it is only a matter of good judgment and sound policy to check important designs by several methods before accepting any one as the basis for construction. It is the purpose of this paper to bring to the attention of civil engineers the effectiveness of the modern photoelastic method in the analysis of statically indeterminate structures in general, and Vierendeel trusses in particular.

It will be assumed that the reader is familiar with the essential equipment and procedure in obtaining a photoelastic stress pattern. We recall first that the fringes, or dark bands in the stress pattern, denote paths or loci of equal maximum shear stress. Second, the numerical values of these stresses are directly proportional to the order of the fringes and can be obtained from $v_{max} = Fn$, in which v_{max} denotes the maximum shear stress, F is a constant known as the fringe value, and n is the fringe order; the latter represents the number of light cycles which have passed through a given point during the gradual application of the loads.

Finally, we recall that at free boundaries there exists only one principal stress and that the photoelastic stress pattern yields directly the numerical value of this principal stress. The photoelastic technique with regard to free boundary stresses has been so perfected in recent years that numerical values of these stresses can now be obtained with very high accuracy. The errors at points of maximum stress need not exceed ±2.5 per cent.

The models of the continuous frames shown in this paper were machined from solid plates of bakelite and their greatest over-all dimensions were about 3 by 1.5 in. The edges were all cut and finished on a home-made milling machine. There was no grinding or lapping of edges. Models can also be made by cementing together straight pieces, or by filing.

The stress patterns shown here are mostly composite pictures of stress patterns of separate parts, matched to form one unit. This was made necessary by the small

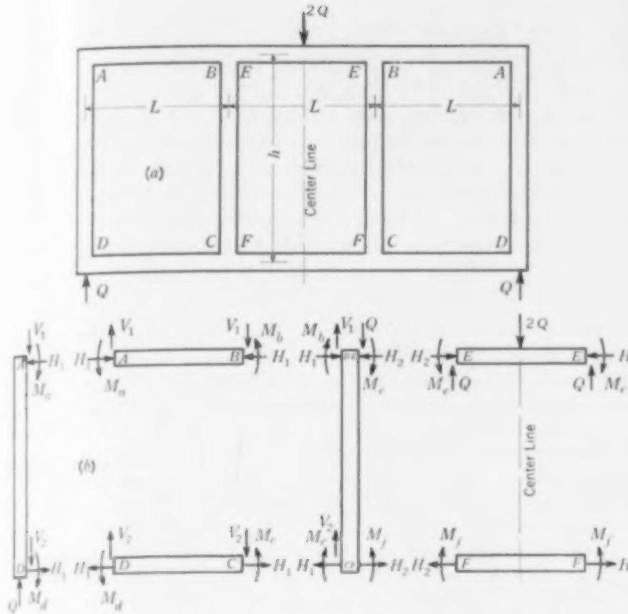


Fig. 1. Three-Panel Vierendeel Truss and Free Body Diagram

lens in the polariscope on which the present work was done; the field in that polariscope being only about 2.5 in. in diameter. However, much larger polariscopes are now available.

In Fig. 1(*a*) is shown a three-panel Vierendeel truss carrying a single concentrated load at the center. The corresponding photoelastic stress pattern is shown in Fig. 2, and comparative curves of the boundary stresses as obtained photoelastically and theoretically are presented in Fig. 3.

From the strain energy theory the following six equations are obtained (see Fig. 1 for notation):

$$M_a + M_b + M_c + M_d = QL$$

$$hM_b - hM_c + (h + L)M_e + (h + L)M_f = QL^2/4$$

$$(h + L)M_a - LM_b + LM_c - (h + L)M_d + LM_e + LM_f = QL^2/4$$

$$(3h + 2L)M_a - LM_b + LM_c - (3h + 2L)M_d = 0$$

Fig. 2. Stress Pattern of Vierendeel Truss, Simply Supported at Lower Ends and Carrying a Concentrated Load at Center of Top

$$2hM_b - hM_c + (2h + 3L)M_e + hM_f = 3QL^2/4$$

$$(2h + 3L)M_a - 3LM_b - hM_d + 3LM_e = 3QL^2/4$$

For the particular loads and dimensions of the truss from which the stress pattern was obtained—namely, $Q = 6.765$ lb, $h = 1.299$ in., and $L = 0.929$ in.—the solution of these equations is: $M_a = 1.50$ lb-in., $M_b = 1.175$ lb-in., $M_c = 1.97$ lb.-in., $M_d = 1.635$ lb-in., $M_e = 0.605$ lb-in., and $M_f = 0.495$ lb-in. The directions of these bending moments are as shown in the free body diagram of Fig. 1(*b*).

For a beam depth of 0.137 in. and a thickness of 0.172 in., the longitudinal stresses at points A, B, C, D, E, and F of Fig. 1(*a*) are computed by the flexure formula to be, respectively, 2,790, 2,180, 3,660, 3,040, 1,125, and 920 lb per sq in. These stresses are the values plotted in the theoretical curves of Fig. 3, and they are in excellent

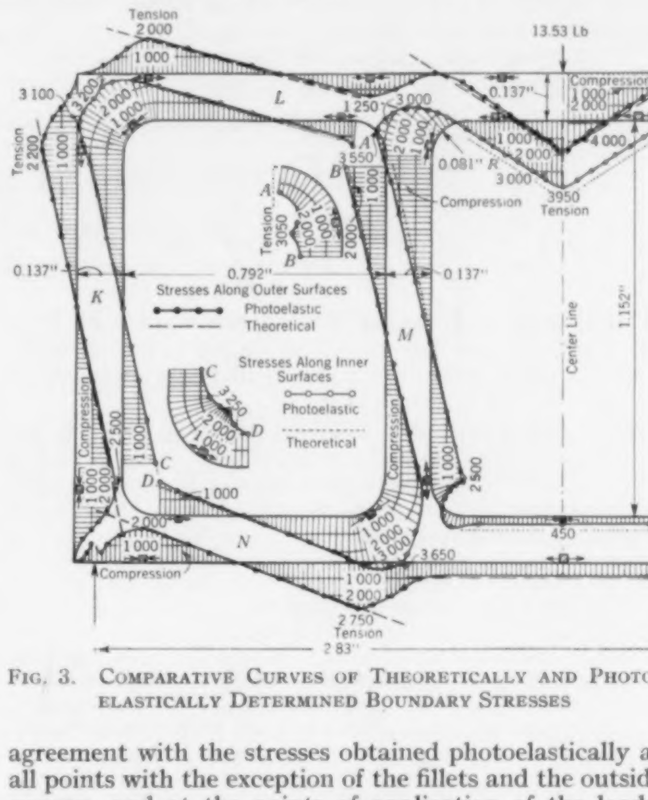


Fig. 3. Comparative Curves of Theoretically and Photoelastically Determined Boundary Stresses

agreement with the stresses obtained photoelastically at all points with the exception of the fillets and the outside corners, and at the points of application of the loads, where the elementary theoretical solution is known to be in error. Thus the tension at the center immediately below the load is 4,700 lb per sq in. theoretically and 3,950 lb per sq in. photoelastically. The compressive stresses in this region are in much closer agreement. Along the end panels the agreement between the results from the two solutions is even closer than in the central panel.

Attention is called to points K, L, M, and N, which are points of zero stress or of contraflexure. These are

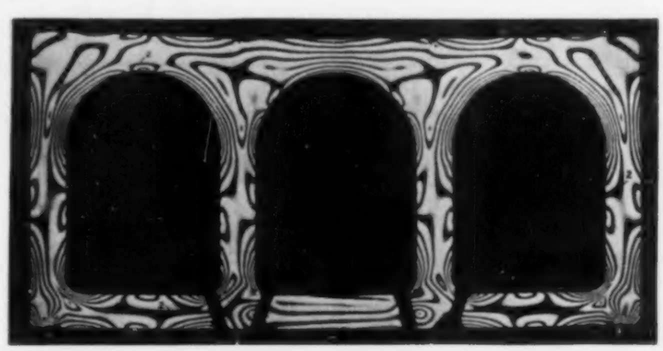


Fig. 4. Stress Pattern of Three-Panel Arched Truss Simply Supported at Lower Ends and Carrying Vertical Loads Beneath the Inner Columns

taken directly from the stress pattern. This result is perhaps of greatest practical significance. The photoelastic method furnishes directly the basic data necessary for a simplified design of statically indeterminate structures.

The significance of these data increases with the complexity of the structure. Figure 4 shows the stress pattern of an arched Vierendeel truss carrying loads beneath the inner columns. As in Fig. 2, this pattern furnishes directly the boundary stresses and points of contraflexure. We note that the only complication which the arch truss introduces is in the preparation of the model. All other aspects of the problem remain as simple as in the case of the truss with straight bars.

We also call attention to the localized high stress or stress concentration at the fillets, which can be determined with a very high degree of accuracy directly from the stress pattern. With the introduction of strong light-weight alloys into structural practice, the civil engineer will have to recognize the significance and importance of stress concentration. The photoelastic method is ideal for the study of this phenomenon.

When the structural members are not strictly two-dimensional but, as is usually the case, consist of I-beams, channels, et cetera, the photoelastic method can be used to determine the bending moments and shears at all sections. This follows from the fact that the bending moments are functions of EI, and not of the specific shapes and dimensions of the cross-section. At sections where there are no discontinuities, the bending moments can be calculated from the observed boundary stresses and the assumption of linear stress distribution.

The Other Side of a Flat Right Triangle

By LEONARD C. JORDAN, M. AM. SOC. C.E.
CONSULTING AND DESIGNING ENGINEER, NEW ROCHELLE, N.Y.

THIS little shortcut for finding the third side of a right triangle has saved me many hours of work. It is especially accurate for flat right triangles in which one known part is the short leg.

Let x and y represent the legs, the latter being the shorter. We wish to find the hypotenuse, z, by adding a small difference, a, to the longer leg, x. Then $z = x + a$, and squaring, $z^2 = x^2 + 2ax + a^2$. Also, $z^2 = x^2 + y^2$. Equating these two values of z^2,

$$a = \frac{y^2}{2x + a}$$

Although this expression looks rather complicated, it is quite convenient for slide-rule work. As an example, suppose $x = 35.32$ and $y = 4.25$. Then $2x = 70.64$. Set the slide rule indicator on 4.25 of the D-scale. The square of this is on the A-scale. Next bring 70.64 of the B-scale under the indicator, add the quotient (from the A-scale) for a new and correct divisor, approximately 70.9, and read the final value of a on the A-scale as 0.255. This is added to x for the value of z as 35.575. The true value of z, found by hard labor, is 35.574779. The accuracy of this method decreases as y becomes relatively larger. However, with fairly careful attention to the slide rule, the result should be correct within 1/10th of 1 per cent when y is as much as $x/2$.

When z and y are known, $x = z - a$, and

$$a = \frac{y^2}{2z - a}$$

The denominator is readily remembered by the fact that when a is to be added to x, the denominator is $2x + a$, while when a is to be subtracted from z, it is $2z - a$.

This method is very satisfactory on structural-steel work in such matters as finding the exact length of ramp beams and in determining the distance between columns along the slant side of a building.

Even though this procedure may appear rather strange, it is actually the same as taking square roots by pencil. For example, to find the square root of 658.43, treat the number as the sum of two squares, $x^2 + y^2$, x being as large as possible. Then $x = 25$, $x^2 = 625$, and the difference (33.43) is y^2. By slide rule, divide y^2 by $2x + a$ and find a to be 0.66. The answer, then, is 25.66 as compared with the slightly more accurate 25.6599.

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

U. S. G. S. Investigates Florida's Ground-Water Supplies

DEAR SIR: The paper by Mr. Stringfield in the July issue presents an excellent general picture of the importance and the occurrence of ground water in Florida. It will help to stimulate more intelligent development and more conservative use of this valuable natural resource. Since 1930 Mr. Stringfield, as the representative of the U. S. Geological Survey in Florida, has been conducting ground-water investigations in cooperation with, as well as independently of, the Florida Geological Survey. Reports have been issued outlining the results obtained, the latest covering the peninsular portion of Florida. The field work for a similar report on western Florida has been completed, and the report will be published in reasonable time, thus completing a general report on this resource for the state as a whole.

The statement that 240 cities and communities of Florida have public water works, and that 210 or more of these obtain their water supplies from wells cannot fail to focus attention on the predominant use of ground water as compared with water from surface sources. There is, however, a difference in the quality of water yielded by wells. Water from those of even moderate depth through a large portion of Florida is hard, and in certain areas is highly mineralized, some well fields having been abandoned on account of salt infiltration. Thus it is not only desirable, but in certain instances necessary, to turn to surface and shallow sources.

The large volume of water used in Florida for irrigation purposes

is not generally known. The trucking and fruit-growing districts depend upon ground water for the successful production of their crops. Were it not for the possibility of obtaining water from flowing wells, these areas would not have been as successful as they are. Deep wells are also used for irrigation but pumping runs the expense up very decidedly. It would be most instructive if statistics on the numbers of wells and the volume of water used for irrigation in Florida were available.

Mr. Stringfield also details the principal water-bearing formations and records their general characteristics. Wells in the Ocala formation have never failed to find water although in some local areas the limestone does become rather close-grained and fails to give water freely, and in some instances it has been necessary to use explosives, generally with favorable results. Other formations are good aquifers, but the Ocala is usually resorted to if large volume and dependable supply are desired.

A result of the cooperative ground-water work has been the preparation of a state map indicating the height to which water will stand in wells. In addition it shows the areas that discharge artesian water and those that absorb it or act as recharge areas. Observations have also been made on the effect of the disposal of large volumes of surface waters through drainage wells. Thus information that will prove of continued and increasing importance in ground-water problems is gradually accumulating.

Florida is generously supplied with ground water but the quality is varied, and in some areas the water is so highly charged with mineral solids as to be unfit for use. These facts have been brought out by Mr. Stringfield, and attention has been called to the urgency of further investigation in certain more critical areas. Another matter which was not thought of until quite recently, is the presence of damaging amounts of fluorides. This must be given further study. It is a satisfaction to know that the chemical quality of our waters is receiving special attention by a group well qualified in such lines of investigation.

HERMAN GUNTER
State Geologist
Tallahassee, Fla.

Methods of Flood Routing

DEAR SIR: In the July issue, I. H. Steinberg described a method of flood routing. I have used a similar method, which appears to produce identical results with fewer computations. Although the methods are in many respects similar, for the sake of clarity the entire derivation will be presented.

The two major assumptions in this method of computing the effect of storage on discharge are, first, that the inflow at the middle of a short period of time is equal to the mean inflow for the period, and, second, that the average of the outflows at the beginning and end of the period is equal to the mean outflow. The nomenclature is as follows:

- Δt = a short period of time
- I = mean inflow to the reservoir during the interval Δt
- O = mean outflow from the reservoir during the interval Δt
- O_1 = outflow rate at the beginning of the period
- O_2 = outflow rate at the end of the period
- S = total storage in the pond measured from any arbitrary elevation
- ΔS = change in storage during the time period
- S_1 = storage at the beginning of the period
- S_2 = storage at the end of the period
- M = $O/2 + S/\Delta t$

From the second assumption, $O\Delta t = {}^1/_2(O_1 + O_2)\Delta t$. For the period of time Δt, inflow minus outflow equals storage, or, $I\Delta t - O\Delta t = \Delta S = S_2 - S_1$. Thus $I\Delta t - {}^1/_2(O_1 + O_2)\Delta t = S_2 - S_1$. Dividing by Δt, splitting, and transposing,

$$I - O_1 + \left(\frac{O_1}{2} + \frac{S_1}{\Delta t}\right) = \left(\frac{O_2}{2} + \frac{S_2}{\Delta t}\right) \qquad [1]$$

or,

$$I - O_1 + M_1 = M_2 \qquad [2]$$

Two elements of this equation deserve special attention. Since the outflow and storage are functions of the stage, the storage is a function of the outflow, and therefore $M = f(O)$. Also if the mean inflow, I, for the period and the initial value of the outflow, O_1, are known, these values, together with a curve showing the relationship of O to M, will determine values of the left-hand member of Eq. 2 and therefore the right-hand member. With the value of M_2 known, it is only necessary to refer to the M-curve to determine the required value of O_2.

The initial step in an actual problem is the computation of the function M from the discharge rating curve and the storage curve. Table I is an example of this computation, the figures in Col. 2 being taken from the rating curve and in Col. 3 from the storage curve.

TABLE I

(1) Stage Ft	(2) O, in Cu Ft per Sec	(3) S, in Cu Ft	(4) $M = \frac{O}{2} + \frac{S}{3{,}600}$ Cu Ft per Sec
6	96	36,000	58
8	280	54,000	153
10		etc.	

This computation combines the rating and storage curves in a single simple function, which is plotted as O against M and is used in Table II in the computation of outflow.

TABLE II

(1) Time Hours	(2) I, in Cu Ft per Sec	(3) $I - O_1 + M_1 = M_2$	(4) O_2 Cu Ft per Sec
0			400
	400	210	
1			400
	500	310	
2			476
	600	434	
3			567

In Table II, Col. 1 lists the time and Col. 2 the mean inflow, I. Col. 3 is the left-hand side (equal to the right) of Eq. 1, and is obtained in a manner to be described later. Col. 4 is the outflow and, as indicated by the spacing, is the value "on the hour," whereas Cols. 2 and 3 are mean values for the hour. The first value in this column—that is, the rate of outflow at the beginning of the computation—must be known. Entering the curve of O against M, we find the value of M_1 to be 210. Adding the mean inflow for the hour and subtracting the initial outflow, we have $210 + 400 - 400 = 210 = I - O_1 + M_1$, which in turn equals M_2. Therefore, by entering the curve O against M with this value, we may obtain the rate of outflow at the end of the hour, $O_2 = 400$.

It is obvious that this outflow at the end of the first hour is also the initial outflow for the second hour, O_1, and the value listed in Col. 3 for the first hour is M_1 for the second hour. Therefore, to obtain O_2 for the second hour we add this value to the inflow for the second hour, subtract the value of O_1 just computed, and enter the curve O against M with the result. The process is continued in this manner until the routing is complete.

It is interesting to note that Mr. Steinberg's problem may be solved by this method, using his curves of M against O, with practically identical results (Table III).

TABLE III

Day	I	Tributary Flow	$M_2 = I - O_1 + M_1$	Outflow
			70,500*	44,300*
1	38,000	6,000		
			64,200	42,000
2	35,000	6,000		
			57,200	39,000
3	31,000	5,000		
			49,200	36,000
4	32,000	4,000		
			45,200	33,500

* Assumed.

The outflow values obtained from Table III fall as close to the curve determined by the values of Mr. Steinberg's Table I as can be expected, considering the fact that the diagram as printed can only be read to two places.

I have found it advantageous to plot the flood-routing diagram with the storage factor, M, as abscissa, since this value must be read for each interval and advantage may be taken of the coordinate ruling for interpolation. It is not usually necessary to determine the value of the storage.

JOHN W. HACKNEY, Jun. Am. Soc. C.E.
Assistant Hydraulic Engineer
Aluminum Company of America
Pittsburgh, Pa.

The Engineer's Part in Malaria Control

To the Editor: Most engineers are familiar with the relation of engineering to public health and with improvements in the control methods applied to a number of communicable diseases that are gradually becoming almost extinct, largely as a result of the engineer's participation in public health work.

A number of the many problems confronting public health officials can best be solved by sanitation engineers. Realizing this fact, state health departments and many county and city health departments now employ one or more experienced engineers whose full time is devoted to solving public health problems of an engineering nature. One of these problems, particularly in the southern states, is the control of malaria.

In his article in the June issue, Mr. Clarkson has discussed this ever-present problem. The medical profession has long been expected to cure malaria rather than to prevent its occurrence. With our present information as to the cause of the disease and the way in which it is transmitted, the physician realizes that it can be prevented and that it is within the province of the trained engineer to accomplish this work.

The control of malaria resolves itself into financing the elimination of malaria-mosquito breeding places. Large sums are being spent for this purpose by the federal, state, county, and city governments, as well as by industrial organizations, and it is necessary to ensure the wise spending of this money. The experienced engineer is qualified to deal with the problems that arise in drainage control and to do so at minimum expense.

Mr. Clarkson has discussed the economic importance of malaria to communities and industrial concerns. I would like to add that more and more communities and industries are realizing the importance of malaria control. For example, the Florida Power Company has a large impounded lake near Tallahassee and is doing fine control work by continuous survey for new breeding during the breeding periods and by dusting with larvicide to prevent breeding. This work is directed by an engineer and is done both on foot and in boats.

Jacksonville, Memphis, Atlanta, and many other cities have financed a mosquito-control set-up. Originally intended for malaria control, these set-ups have been extended to cover the entire mosquito situation. Where communities do not have their own set-up, the state board of health is supplying technical advice and supervision and its health department is also cooperating with existing engineering personnel.

The importance of guarding against the creation of malaria-mosquito breeding places in construction work of any nature cannot be overemphasized. Those of us who have found it necessary to relieve conditions created by improper construction realize that often the expense incurred and the difficulties encountered are much greater than they would have been had malaria hazards been eliminated at the time of original construction.

If construction engineers understand the basic principles of malaria propagation and transmission, conditions suitable for mosquito breeding will be eliminated in future construction. Therefore, it is our duty to stress the fact that malaria is transmitted only by the mosquito and by only one of the many varieties of mosquitoes. This family of mosquitoes has distinct characteristics common to this group alone and easily recognized even by the layman. It must be remembered that the one basic requirement for the breeding of mosquitoes is water. Of course, different types of mosquitoes—and there are approximately 500 species—prefer different places for laying their eggs. For example, malaria mosquitoes will rarely breed in artificial containers, such as tin cans, or in polluted water, but prefer comparatively clear water with slight motion and a certain amount of shade, but all must have water. Therefore, if care is taken that construction work of any nature does not leave behind standing water and that drainage plans for railway and highway right of ways allow for grading to a sufficient level to permit their use as land drainage outlets, the value of the work to the inhabitants of the community will be greatly increased.

H. D. Peters
Sanitation Engineer, City Health Department

Jacksonville, Fla.

Curious Railways of Other Days

Dear Sir: In recent numbers of Civil Engineering I have been interested to read letters by C. D. Purdon, M. Am. Soc. C.E., regarding some curious railways of earlier days.

One of Mr. Purdon's examples was the Lartigue mono-rail line in Ireland, which he suggested bore some relation to the development of the gyroscope. That line was built long before the development of the gyroscope for balancing, and was what might be called a "pack-saddle" railway. The structure consisted of light steel A-frame bents about $4^1/_2$ ft high, connected by a top beam on which was laid the traction rail, and by a guide rail on each side, at about mid-height. The car frames straddled this structure and were carried by wheels on the top rail, while horizontal wheels ran against the side rails. Passengers sat on both sides, with their backs to the structure. The steam locomotive had two small boilers, one on each side of the pack-saddle frames.

Another mono-rail system was the Meigs elevated railway, proposed for Boston rapid transit. A full-size specimen was built in the form of a loop for demonstration on an empty lot, and I had the pleasure of a trip on it. A row of columns supported a single line of girders, the car trucks straddling these and having carrying wheels riding on the top rail, while guide wheels set at 45 deg ran on rails on the bottom chord. The cars and locomotive were cylindrical, sheathed with copper, with hemispherical ends. The engine had horizontal driving wheels gripped against the top rail, and the crank pins were driven by the reciprocating motion of a slotted plate, or "Scotch yoke," instead of by a connecting rod.

Then there was the Green Mountain rack railway on Mount Desert Island, or Bar Harbor, Me. This was a copy of the Mount Washington railway, but of lesser length and height. The line was abandoned long ago.

Also in Maine there were formerly several light railways of 2-ft gage, among them the Bridgeton & Saco River, the Franklin & Megamtic, and the Sandy River. All these have been abandoned. On a trip over the first named I met the chief engineer, and asked the reason for adopting the 2-ft gage. His reply was: "We could not afford a horse, so we bought a donkey."

The rack used on the Pike's Peak railway was of the Abt type, composed of flat bars with toothed upper edge, two or more bars being packed side by side with teeth slightly staggered. The cog wheel or drum on the engine had a similar number of rows of teeth, staggered in the same way, so that several teeth were always in mesh. This was a marked improvement over the Marsh type of ladder rack as used on the Mount Washington and Green Mountain railways.

In more recent years, when a South-Side water-works intake shaft and tunnel were being built at Chicago, the contractor, the late George Jackson, installed an aerial tramway from the shore to the shaft, and had some of the buckets fitted up to carry passengers. At one time he invited a number of officials to visit the work, but according to report the vertical motion of the sags between the supporting towers and the swaying motion due to wind, so excellently reproduced wave action on a ship at sea that few of the passengers had much interest in the elaborate luncheon provided.

The pneumatic railway idea was revived some years ago by a promotor who proposed a rapid-transit line for Chicago. He built a concrete tunnel for demonstration at a summer resort at Forest Park, and operated it partly as a concession, charging a small fare. Fragments of the tunnel still exist.

Incidentally, it is rather curious that with such a vast area of "scenic" mountain country, the United States has so few of the scenic railways that are numerous on the continent of Europe. These include rack-rail and cable lines, and aerial tramways. In Great Britain there are two such lines—the Snowdon rack-rail line and the Snaefell line (on the Isle of Man) on the Fell grip-rail system.

E. E. R. Tratman, Assoc. M. Am. Soc. C.E.
Civil Engineer

Wheaton, Ill.

Fall Meeting in Rochester, N.Y.

Hotel Seneca to Be Headquarters, October 12–14, 1938

Program of Meetings, Entertainment, and Trips

Opening Session and General Meeting

WEDNESDAY—October 12, 1938—Morning

9:00 **Registration**

9:30 **Fall Meeting called to order by**

William H. Roberts, *Assoc. M. Am. Soc. C.E., President, Rochester Section, Am. Soc. C.E.; Commissioner of Public Works*, Rochester, N.Y.

9:35 **Address of Welcome**

Harold W. Baker, *M. Am. Soc. C.E., City Manager*, Rochester, N.Y.

9:50 **Response**

Henry E. Riggs, *President, American Society of Civil Engineers; Honorary Professor, Civil Engineering, University of Michigan*, Ann Arbor, Mich.

10:10 **Development of Structural Analysis Over Three Centuries—In Commemoration of the 300th Anniversary of the Beginning of Modern Structural Theory**

S. C. Hollister, *M. Am. Soc. C.E., Dean, College of Engineering, Cornell University*, Ithaca, N.Y.

Business Meeting

12:30 **Luncheon Recess**

WEDNESDAY—October 12, 1938—Afternoon

WATERWAYS DIVISION

William G. Atwood, *Chairman, Executive Committee, Presiding*

FLOOD CONTROL STUDIES AND WORKS FOR NEW YORK STATE RIVERS

2:00 **Hydraulic Model Tests for the Southern New York Flood Control Project**

George J. Nold, *Major, Corps of Engineers, U.S.A.; District Engineer*, Binghamton, N.Y.

2:25 **Discussion opened by**

E. W. Schoder, *M. Am. Soc. C.E., Professor, Experimental Hydraulics, Cornell University*, Ithaca, N.Y.

2:40 **Genesee River Flood Control and Related Problems**

E. A. Fisher, *Hon. M. Am. Soc. C.E., Consulting Engineer*, Rochester, N.Y., *and* P. A. Covas, *Assoc. M. Am. Soc. C.E., Assistant Engineer, Department of Public Works*, Rochester, N.Y.

3:05 **Discussion opened by**

Henry L. Howe, *M. Am. Soc. C.E., City Engineer, Department of Public Works*, Rochester, N.Y.

3:20 **Results of the Operation of the Sacandaga Reservoir in Regulating the Hudson River**

E. H. Sargent, *M. Am. Soc. C.E., Chief Engineer, Hudson River Regulating District*, Albany, N.Y.

3:45 **Discussion opened by**

E. S. Cullings, *M. Am. Soc. C.E., Secretary and Chief Engineer, Black River Regulating District*, Watertown, N.Y.

4:00 **General Discussion**

STRUCTURAL DIVISION

Charles F. Goodrich, *Member, Executive Committee, Presiding*

THE THOUSAND ISLANDS BRIDGE PROJECT

2:00 **History of the Project**

William T. Field, *M. Am. Soc. C.E., President and Treasurer, The William T. Field Engineers, Inc.*, Watertown, N.Y.

2:10 **Design and Construction of the Thousand Islands Bridge**

D. B. Steinman, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

2:40 **Discussion opened by**

Chauncey M. Goodrich, *M. Am. Soc. C.E., Chief Engineer, The Canadian Bridge Company, Ltd.*, Walkerville, Ontario, Canada.

R. Boblow, *Assoc. M. Am. Soc. C.E., Civil Engineer, Robinson and Steinman*, New York, N.Y.

3:45 **Structural Features of the New York Central Grade Separation Project in Syracuse**

Nelson F. Pitts, *M. Am. Soc. C.E., Chief Engineer, Syracuse Grade Crossing Commission; City Engineer*, Syracuse, N.Y.

4:15 **Discussion opened by**

George S. Minniss, *M. Am. Soc. C.E., Chief Engineer, Grade Crossing and Terminal Station Commission*, Buffalo, N.Y.

WEDNESDAY—October 12, 1938—Evening

7:00 Dinner and Dance for Members, Ladies, and Guests at Hotel Seneca

Tickets for the dinner and dance are $3.00 each. Tickets for Students and Juniors to the dance only are $1.50 per couple.

Morning Sessions of Technical Divisions

THURSDAY—October 13, 1938

POWER DIVISION

A. V. KARPOV, *Consulting Engineer, Presiding*

POWER DIVISION SYMPOSIA

The Power Division, in line with the changing general attitude toward power problems, embarked on a program of two different kinds of symposia, one which leans toward the economic phases and the other toward the technical aspects of the power problem.

ECONOMIC SYMPOSIA

The October 1936 Symposium on Economic Aspects of Energy Generation, the January 1938 Symposium on Cost of Power, and the proposed Symposium on Ultimate Cost of Power to the Consumer, represent the work of the Division toward clarifying the economic phases.

TECHNICAL SYMPOSIA

The present Symposium on Power Plant Design and Efficiency, and the proposed April and July 1939 Symposium on Masonry Dams, represent the work of the Division in advancing the art of engineering by a critical analysis of the new developments and trends.

SYMPOSIUM ON POWER PLANT DESIGN AND EFFICIENCY

9:30 Power Plant Space and Cost Trends

H. G. GERDES, *M. Am. Soc. C.E., Consulting Engineer,* Charleston, S.C.

10:00 Turbine Model and Prototype Tests

L. M. DAVIS, *Assoc. M. Am. Soc. C.E., Engineer, Pennsylvania Water and Power Company,* Holtwood, Pa.

10:30 Initial Investigations and Economical Planning of Hydro-Electric Plants

A. T. LARNED, *M. Am. Soc. C.E., Civil and Hydraulic Engineer, Phoenix Engineering Corporation,* New York, N.Y.

11:00 Discussion

11:15 Discussion opened by

LAZARUS WHITE, *M. Am. Soc. C.E., President, Spencer, White and Prentis, Inc.,* New York, N.Y.

DONALD M. BURMISTER, *Assoc. M. Am. Soc. C.E., Assistant Professor, Civil Engineering, Engineering School, Columbia University,* New York, N.Y.

11:35 General Discussion

11:45 Adjournment to following morning

SOIL MECHANICS AND FOUNDATIONS DIVISION

CARLTON S. PROCTOR, *Chairman, Executive Committee, Presiding*

9:30 Opening Address

CARLTON S. PROCTOR, *M. Am. Soc. C.E., Consulting Engineer,* New York, N.Y.

9:40 The Practical Application of Soil Mechanics in Substructure Problems

GEORGE L. FREEMAN, *M. Am. Soc. C.E., Consulting Engineer,* New York, N.Y.

10:10 Discussion opened by

MAJOR IRVING V. A. HUIE, *M. Am. Soc. C.E., Chief Engineer and Acting Deputy Commissioner, Department of Public Works,* New York, N.Y.

WILLIAM P. KIMBALL, *Assoc. M. Am. Soc. C.E., Assistant Professor, Civil Engineering, Thayer School of Civil Engineering, Dartmouth College,* Hanover, N.H.

10:30 General Discussion

10:40 Recess

10:45 Settlement Studies of Structures

GREGORY P. TSCHEBOTAREFF, *M. Am. Soc. C.E., Assistant Professor, Civil Engineering, School of Engineering, Princeton University,* Princeton, N.J.

SANITARY ENGINEERING DIVISION

ARTHUR D. WESTON, *Member, Executive Committee, Presiding*

9:30 Progress in the Control of Water Pollution in New York State

A. F. DAPPERT, *Principal Sanitary Engineer, Division of Sanitation, New York State Department of Health,* Albany, N.Y.

10:00 Discussion opened by

CHARLES L. WALKER, *M. Am. Soc. C.E., Professor, Sanitary Engineering, Cornell University,* Ithaca, N.Y.

SETH G. HESS, *M. Am. Soc. C.E., Chief Engineer, Interstate Sanitation Commission,* New York, N.Y.

10:30 Ley Creek Sanitary District and Activated Sludge Treatment Plant at East Syracuse, N.Y.

GLENN D. HOLMES, *M. Am. Soc. C.E., Director-Chief Engineer, Onondaga County Sanitary Sewer and Public Works Commission,* Syracuse, N.Y.

10:50 Discussion opened by

KENNETH J. KNAPP, *Sanitary Engineer,* Rochester, N.Y.

11:05 Buffalo's New Sewage Disposal Plant

SAMUEL A. GREELEY, *M. Am. Soc. C.E., Consulting Engineer,* Chicago, Ill.

11:25 Discussion opened by

P. B. STREANDER, *M. Am. Soc. C.E., Consulting Engineer,* New York, N.Y.

CHARLES A. HOLMQUIST, *Commissioner of Sanitation, State Department of Health,* Albany, N.Y.

SENECA PARKWAY, ROCHESTER RESIDENTIAL SECTION

Afternoon Inspection of Eastman Kodak Works

THURSDAY—October 13, 1938

Members, **ladies and guests will leave the Hotel Seneca by bus** at 12:30 p.m. **sharp for the plant of the Eastman Kodak Company,** going directly **to the restaurant for luncheon. Following luncheon,** the group **will inspect the plant. Note that an inspection of Kodak** Park for **the ladies only is arranged for Friday afternoon.**

Kodak Park is the largest of 13 manufacturing units of the Eastman Kodak Company located in all parts of the world. It is one of three Rochester factories in addition to the main offices which are also located here. Film, paper, plates, and chemicals are included in the more than 3,500 different products made at Kodak Park. Kodaks and projectors originate at the Camera works; lenses are manufactured at the Hawk Eye plant.

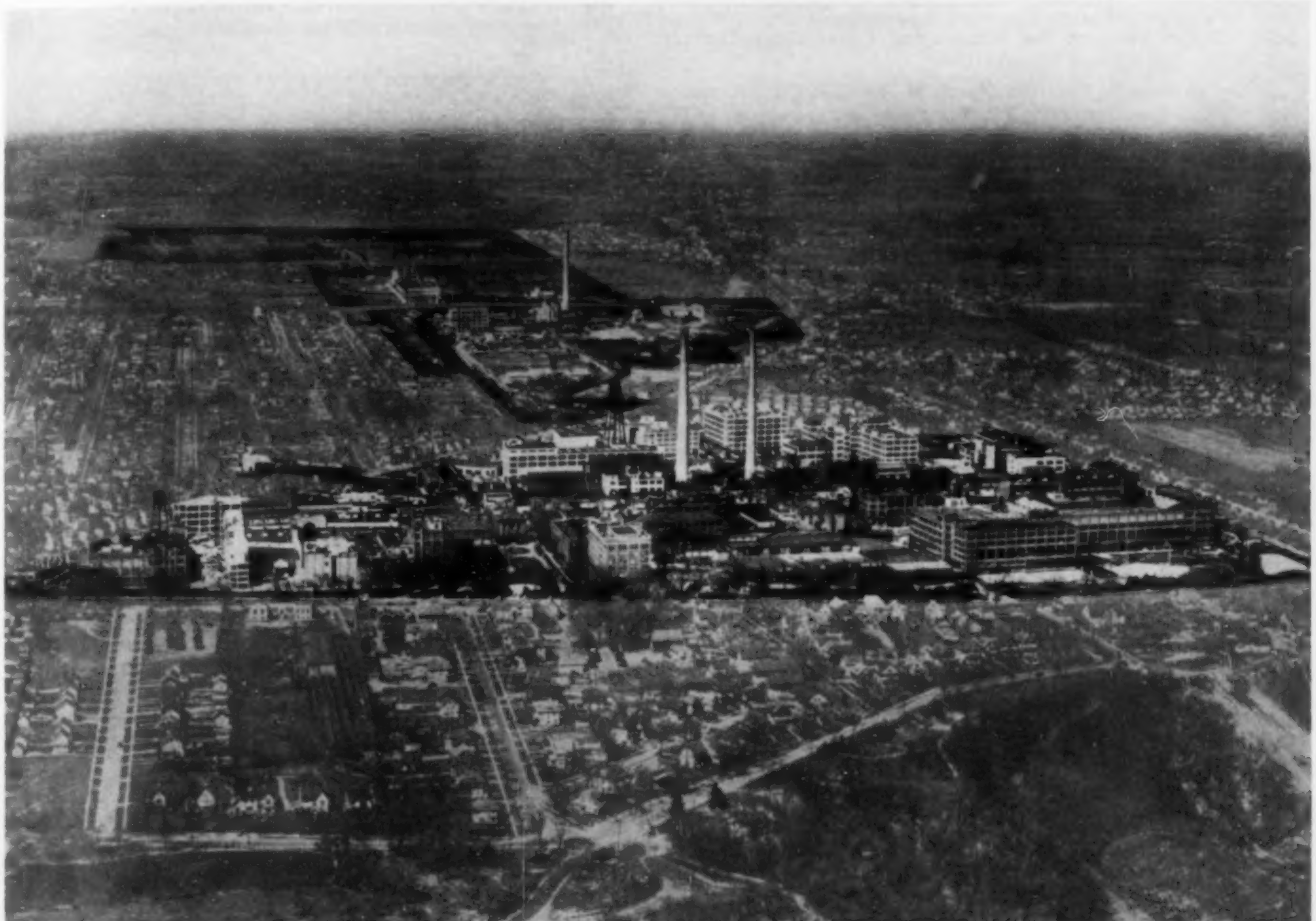
Ninety buildings, containing more than 5,742,000 sq ft of floor space, stand on a part of the 400-acre plot that is Kodak Park. This city within a city has about 9 miles of streets, 9 miles of railroad, 25 miles of water mains, and employs about 10,500 people. It operates its own power, fire, and medical departments, fireless railroad, garage, laundry, and cafeterias that serve more than 4,000 meals per day.

The visitors will inspect modern laboratories for production testing, the largest interconnected refrigeration plant in the world, and an 850-lb boiler and accessories for generating a part of Kodak Park's electricity. Roll film spooling in air-conditioned dark rooms, automatic film packaging, continuous manufacture of red and black paper from wood pulp will show production engineering and technique. Considerable time will be spent in the engineering and maintenance department which services the plant in the design, construction, and maintenance of plant facilities, including building, machinery and mechanical equipment, power and water supply, and the stocking of equipment and material for these purposes. In the machine shop large planers, turret lathes, milling machines, gear hobbers, and boring mills, as well as a fully equipped tool room and heat-treating department will be in operation. The metal shop equipment in operation will include the large modern seam and spot welder, some of the 57 portable electric welding machines, carbon arc, and gas welding equipment, shears, Cincinnati brake for bending large metal sheets, punch and drill presses, power rolls, and the grinding and polishing room.

The attention of members is directed to the fact that no matches, cigar or cigarette lighters, flashlights, etc., may be taken on the grounds of the company.

The party will be returned to the Hotel Seneca about 4:30 p.m.

Tickets for the trip, including luncheon, are $1.50.



Air View of Kodak Park Works, Eastman Kodak Company

THURSDAY—October 13, 1938—Evening, 8:00 p. m.

Entertainment at the Eastman Theater for Members, Ladies, and Guests

Musical program and address on Color Photography by Dr. C. E. K. Mees, *Vice-President in Charge of Research and Development, Eastman Kodak Company.* There will be no charge for tickets. For detailed information, see page 696.

Morning Sessions of Technical Divisions

FRIDAY—October 14, 1938

POWER DIVISION

A. V. KARPOV, *Consulting Engineer, Presiding*

CONTINUATION OF SYMPOSIUM ON POWER PLANT DESIGN AND EFFICIENCY

9:30 Progress and Economical Principles of Design of Turbines and Appurtenances

I. A. WINTER, *Assoc. M. Am. Soc. C.E., Senior Engineer, U. S. Bureau of Reclamation*, Denver, Colo.

10:00 Preliminary Selection of Hydraulic Turbines and Power House Dimensions

W. L. VOORDUIN, *Assoc. M. Am. Soc. C.E., with TVA*, Knoxville, Tenn.

10:30 Discussion

SOIL MECHANICS AND FOUNDATIONS DIVISION

CARLTON S. PROCTOR, *Chairman, Executive Committee, Presiding*

9:30 Soil Studies at the Muskingum Conservancy District, Theory and Observation

ROBERT R. PHILIPPE, *Assoc. M. Am. Soc. C.E., Engineer U. S. Engineer Office*, Pittsburgh, Pa.

10:00 Discussion opened by

JOEL D. JUSTIN, *M. Am. Soc. C.E., Consulting Engineer, Philadelphia, Pa.*

GLENNON GILBOY, *Assoc. M. Am. Soc. C.E., Associate Professor, Soil Mechanics. Massachusetts Institute of Technology*, Cambridge, Mass.

10:20 General Discussion

10:30 Recess

10:35 Application of Soil Mechanics and Foundation Engineering on the Fort Peck Dam

THOMAS A. MIDDLEBROOKS, *Assoc. M. Am. Soc. C.E., Senior Engineer, Board of Engineers for Rivers and Harbors*, Washington, D.C.

11:05 Discussion opened by

JOHN P. HARTMAN, *Jun. Am. Soc. C.E., Associate Engineer, U. S. Engineer Office*, Louisville, Ky.

F. B. SLICHTER, *Engineer, U. S. Engineer Office*, Kansas City, Mo.

11:25 General Discussion

11:45 Adjournment

BROAD STREET, ROCHESTER, SUPPORTED BY AQUEDUCT OVER GENESEE RIVER

CITY PLANNING DIVISION

HAROLD M. LEWIS, *Chairman, Executive Committee, Presiding*

SYMPOSIUM ON URBAN TRAFFIC CONTROL

9:30 Introductory Paper—Engineering Aspects

DR. MILLER MCCLINTOCK, *Director, Bureau for Street Traffic Research, Yale University*, New Haven, Conn.

10:00 Traffic Control Problem as Related to Buffalo

ELWIN G. SPEYER, *M. Am. Soc. C.E., Consulting and Construction Engineer*, Buffalo, N.Y.

10:20 Traffic Control Problem as It Relates to Rochester and Vicinity

LEON R. BROWN, *M. Am. Soc. C.E., Research Engineer, Rochester Transit Corporation*, Rochester, N.Y.

10:40 Discussion opened by

BURTON W. MARSH, *M. Am. Soc. C.E., Director, Safety and Traffic, Engineering Department, American Automobile Association*, Washington, D.C

A. W. BRANDT, *Commissioner of Highways*, Albany, N.Y.

HAWLEY S. SIMPSON, *M. Am. Soc. C.E., Research Engineer, American Transit Association*, New York, N.Y.

ELMWOOD AVENUE BRIDGE OVER THE GENESEE RIVER, ROCHESTER

Afternoon Inspection Trips to Points of Local Interest

FRIDAY—October 14, 1938

2:00 **Inspection Trips**

Arrangements have been made for members and guests to go on the following trips. Both trips will start from the Hotel Seneca at 2:00 p.m. sharp.

(1) Bausch and Lomb Optical Company and Taylor Instrument Company

(2) Rubbish Disposal Plant and Irondequoit Sewage Treatment Plant

Tickets for the above trips are 75 cents each.

Bausch and Lomb Optical Company

Bausch and Lomb Optical Company, whose business was founded in 1853, is outstanding in the manufacture and sale of optical and scientific instruments, spectacle lenses and frames, and other ophthalmic products. Its principal plant and offices are located in Rochester, N.Y., and consist of 29 buildings, with over 1,000,000 sq ft of floor space. About 3,200 people, including workmen skilled through many years of training, are employed in the principal plant and offices.

In addition to its ophthalmic products, the company now produces over 2,000 instrument items, including microscopes, optical measuring instruments for industrial inspection and control, and for chemical laboratories, photomicrographic equipment, reflectors, binoculars, spotting telescopes, projection apparatus, and other optical control instruments.

Prior to the World War there was no optical glass manufactured commercially in the United States. During the World War, working in conjunction with experts of the U. S. Government and of the Carnegie Institute, the company undertook the manufacture of optical glass and now produces in its own glass plant various types of optical glass for its scientific instruments, as well as its entire requirements for spectacle lenses.

The points of interest on this inspection are too numerous to mention in full. Visitors will have the opportunity of seeing the assembly and inspection of microscopes, refractometers, colorimeters, photomicrographic and X-ray apparatus, and many other special optical instruments.

Visitors will be taken through the shops to see the numerous operations performed by automatic machines, turret lathes, and diamond turning processes. Other points of interest include optical methods in tool inspection, manufacture of lenses, the chemical laboratory, the departments where the operations in making, inspecting, and assembling eyeglass frames are conducted.

Taylor Instrument Company

In the field, the office, or the home, most of those who take this trip have found a faithful ally in at least one of the numerous products made by the Taylor Instrument Company.

Over 8,000 different instruments are manufactured for the measurement or control of temperature, pressure, specific gravity, rate of flow, and liquid level. Other products of particular interest to the civil engineer include Short and Mason aneroid altitude barometers, mercurial barometers, miner's compasses, Abney levels, gas lead detectors, anemometers, hygrodeiks, etc.

Few plants utilize a greater diversity of arts and crafts, approximately every twelfth employee being a scientist.

Visitors will be fascinated by the art of making precision glass thermometers for clinical and laboratory use, and the meticulous routine which assures their permanent accuracy. In the making of the more mechanical instruments, the elaborate tooling and gaging departments exert a similar influence. A modern machine shop for producing the mechanical parts assures consistently high quality.

A high light of the trip through this plant is the exceedingly modern demonstration room where instruments in actual operation display the latest refinements in design and operating principles.

Rubbish Disposal Plant

In June of 1938, the city began operation of a new rubbish incinerating plant which replaces a combined rubbish salvage and incinerating plant constructed in 1911.

The plant consists of a dumping floor; storage pit with a capacity of 1,800 cu yd; traveling electric crane and grab bucket; charging floor; stoking floor at which level are located two refractory-type furnaces of a nominal daily capacity of 100 tons each, and two 420-hp waste heat boilers; an ash tunnel at grade; and a radial brick chimney which is 250 ft in height.

The entire plant is housed within a reinforced concrete, brick, and structural steel building with Indiana limestone trim. The auxiliaries include induced and forced draft fans; a feedwater heater; centrifugal and reciprocating feedwater pumps; steam flowmeters, pyrometers, and other miscellaneous recording instruments; air-operated charging devices; hydraulically operated ash-gates; and other modern equipment.

The steam generated through the utilization of the heat in the waste gases from the furnaces is diverted to the adjacent garbage reduction plant and used in the straight Cobwell system of reduction. The latter plant has been in continuous operation since October 1921.

Irondequoit Sewage Treatment Plant

The Irondequoit sewage treatment plant was constructed during 1915–1916 and placed in operation in April 1917. An addition to the plant, consisting of a duplication of the original number of sedimentation tanks and area of sludge drying beds was made during 1934–1935 and began operation in June 1936.

The plant consists of coarse racks, 6 detritus tanks, 6 Reinsch-Wurl ype fine screens, 20 Imhoff sedimentation tanks, together with 80 open sludge drying beds, a hydraulic power house, an industrial railway system, and other appurtenances.

The plant treats the combined sewage flow from a territory of about 21,000 acres within and adjacent to the city and serves an estimated population of 315,000 persons. Effluent from the plant is discharged into Lake Ontario at a distance of 7,000 ft from shore and at a depth of about 35 ft.

At the time of construction, the Imhoff tank installation was one of the largest in the United States. At the present time, the chief interest in the plant lies in the fact that it provides adequate treatment to meet local and state sanitary requirements at a low yearly cost for operation as compared with the more recent and complex methods of sewage treatment.

IRONDEQUOIT SEWAGE TREATMENT PLANT

Entertainment for the Ladies

WEDNESDAY—October 12, 1938

Morning

On arrival at Hotel Seneca there will be a committee of Rochester ladies to welcome the ladies attending the meeting.

12:30 **Get Acquainted Luncheon in the Pompeian Room at Hotel Seneca**

Tickets $1.00.

Afternoon

1:30 **Motor Tour of Rochester's Residental District, Parks, and Lake Shore**

Rochester, known as the "Flower City," boasts of its many beautiful parks, flowers tree-lined streets, handsome homes, and lovely gardens.

4:00 **A Visit to Memorial Art Gallery and Tea**

No charge for tickets

During the visit and inspection of the collection there will be a talk by the curator. Tea will be served in the Fountain Room.

Evening

Dinner and Dance, Ball Room, Hotel Seneca, for Members, Ladies and Guests

Complete information will be found elsewhere.

THURSDAY—October 13, 1938—Morning and Afternoon

Motor Drive to Niagara Falls and Old Fort Niagara, with Luncheon at Fort Niagara Officers' Club, Returning About 5:30 p.m.

Tickets, including lunch, $4.00.

No one should miss this trip to America's most beautiful spot, Nature's masterpiece—Niagara Falls—nor a visit to Old Fort Niagara, which has been recently restored. It is one of the first fortifications on the Niagara frontier. It was prominent during the French and Indian Wars, when it was occupied by the French; later it came into the possession of Great Britain, finally into the hands of the United States. The recent restoration of the old fort is in accordance with the original plans discovered in the archives in Paris at the close of the World War. Customarily, the flags of France, Great Britain, and the United States all fly at Old Fort Niagara. Guides will explain the fascinating history of this old fortification.

The present post is occupied by a garrison of United States Infantry. Luncheon for the party will be served at the Officers' Club.

Evening

Entertainment scheduled on the program is for members, ladies, and guests.

FRIDAY—October 14, 1938

Luncheon and Afternoon

12:00 **Luncheon at "The Hale House," Lake Avenue**

Tickets $1.00.

2:00 **Tour of Inspection to Kodak Park**

Kodak Park—A description of the plant of the Eastman Kodak Company appears elsewhere in the program. The Friday afternoon inspection is arranged especially for the ladies.

Cars will leave the Hotel Seneca promptly at 11:30 a.m. to take the ladies to lunch, later taking them to Kodak Park. The party will return to the Seneca about 5:00 p.m.

Tickets for all ladies' events may be obtained at the Registration Desk on arrival. Ladies are requested to make reservations as early as possible.

Thursday Evening Entertainment for Members, Ladies, and Guests, at Eastman Theater, 8 p.m.

The program will be divided into two sections. Between these sections there will be a promenade intermission in the adjacent corridors of the Eastman School of Music.

The first section will be an address on "Color Photography" by Dr. C. E. Kenneth Mees, vice-president in charge of research and development, Eastman Kodak Company, one of the nation's foremost scientists. This address will be illustrated by slides and moving pictures, showing various processes of color photography, including the Kodachrome process developed in the Eastman Laboratories.

The second section will be a musical program of six numbers, illustrative of the musical activities for which Rochester is well known. Two numbers will be by the Eastman School of Music Orchestra of approximately one hundred pieces under the direction of Mr. Paul White. The remaining four numbers will be by the Madison High School A Cappella Choir of one hundred and twenty pupils under the direction of Mr. J. Alfred Casad.

Tickets will be required, but there will be no charge.

The Eastman Theater is five minutes' walk from the Seneca Hotel, headquarters of the Convention.

RUNDELL MEMORIAL LIBRARY BUILDING, ROCHESTER

OLD FORT NIAGARA FLIES THREE FLAGS

Hotel Accommodations and Announcements

In order to be certain of accommodations, members are urged to make definite arrangements for rooms at least a week in advance of the Fall Meeting, paying for the rooms in advance for at least a part of the period for which they expect to be in Rochester.

Hotel Rates

Hotels	Single Room	Double Room
Seneca*	$2.50 up	$4.00 up
Powers*	2.00 up	4.00 up
Rochester*	3.50 up	5.00 up
Sagamore	3.00 up	4.00 up

The rates quoted are the prices per day for a room with private bath. Hotels marked with an asterisk also have rooms without private bath at lower rates.

The Hotel Seneca is the Meeting Headquarters, and it is expected that it will be able to care for all who attend.

Reservations are to be made directly with the hotel as early as possible in order to prevent delay and inconvenience in obtaining accommodations on arrival. When making reservations, state kind of room desired, that is, single room inside; single room outside; double room inside, double bed; double room outside, double bed; double room inside, twin beds; double room outside, twin beds. Hotel will make acknowledgment of reservation direct to member.

All who attend the Fall Meeting are requested to register immediately upon arrival at Meeting Headquarters. Special badges and tickets will be obtained at the time of registration.

Local Sections Conference

A conference of representatives of the thirty-one Local Sections in the Northern Meeting Region will meet at 9:30 a.m. on Tuesday, October 11, 1938, in the Hotel Seneca. The program will schedule topics of professional rather than technical interest, in which all representatives are expected to participate. All members of the Society are welcome to attend.

Invitation to Student Members

Members of Student Chapters are invited to participate in all the events of the Fall Meeting.

Order All Tickets in Advance

Members who order tickets in advance not only will be saved delay by having tickets and badges awaiting them on arrival at Meeting Headquarters, but they will assist the committee greatly by giving advance information to guide it in concluding arrangements.

Information

A Registration Desk will be provided in the headquarters hotel to assist visiting members in securing desired information about the city. At the Registration Desk a card file of those in attendance will be maintained, with information as to Rochester addresses.

Entertainment for the Ladies

Attention is directed to the entertainment provided for the ladies on Wednesday, Thursday, and Friday. It is expected that they will participate with the members in any other features of the program in which they are interested.

Special Trips or Arrangements

Members desiring to play golf or to take trips to points of individual interest are requested to consult the Registration Desk regarding such arrangements.

Local Committees on Arrangements

General Committee

Carey H. Brown, *Chairman*

P. A. Covas — P. Waller
N. H. Davidson — R. R. Sheridan

Cooperating Committee, Western New York Sections

Stewart S. Neff, *Chairman*

F. A. Barnes, Ithaca — W. F. Kavanaugh, Syracuse
W. T. Field, Watertown — A. R. Reilly, Rochester
Nelson Stone, Buffalo

Technical Program

Carl C. Cooman, *Chairman*

J. F. McManus — W. F. Pond
I. E. Matthews — A. L. Vedder

Finance

A. Harold Metcalfe, *Chairman*

H. A. Abell — Thomas Leach
J. C. Bell — W. S. Little
F. W. Fisher — H. A. Zollweg

Hotel and Registration

Eldred H. Walker, *Chairman*

H. P. Cramer — L. M. Sanford
E. L. Oliver — C. F. Starr

Entertainment

Robert B. Jeffers, *Chairman*

C. E. Elmendorf — H. L. Howe
J. B. Reinhardt

Excursion and Inspection

George C. Wright, *Chairman*

L. R. Brown — B. H. Palmer
M. D. Hayes — L. B. Smith
A. H. Wagener

Ladies Committee

Mrs. Carey H. Brown, *Chairman*
Mrs. William H. Roberts, *Assistant Chairman*
Mrs. Henry L. Howe, *Assistant Chairman*

Mrs. Harold W. Baker — Mrs. T. Leach
Mrs. F. Barnum — Mrs. W. S. Little
Mrs. J. C. Bell — Mrs. E. L. Oliver
Mrs. C. C. Cooman — Mrs. B. H. Palmer
Mrs. N. H. Davidson — Mrs. C. Arthur Poole
Mrs. R. de Charms — Mrs. A. R. Reilly
Mrs. C. E. Elmendorf — Mrs. R. R. Sheridan
Mrs. S. C. Hollister — Mrs. C. F. Starr
Mrs. J. Howe — Mrs. Eldred Walker
Mrs. R. B. Jeffers — Mrs. P. Waller

The program as a whole has been prepared under the direction of the Committee on Regional Meetings, composed of Malcolm Pirnie, *Vice-President, Am. Soc. C.E., Chairman;* and L. E. Ayres, Arthur W. Dean, W. W. DeBerard, A. W. Harrington, C. E. Myers, and J. E. Root, *Directors, Am. Soc. C.E.*

Please call on the Local Committee on Arrangements or on the Secretary's office for any service desired.

For Advance Registration Card and Ticket Order See page 27 of Advertising Section

SOCIETY AFFAIRS

Official and Semi-Official

District 7 Enjoys Meeting at Houghton, Mich.

By L. C. Wilcoxen, Assoc. M. Am. Soc. C.E.

Secretary-Treasurer, Michigan Section

Members residing in District 7 gathered at Houghton, Mich., on August 25 for a three-day summer meeting—the first of its kind in that section of the country. The program opened at the new Eagle Harbor Golf Club, and the drive to its location, in the heart of the scenic Keweenaw Peninsula and the copper country, was an inspiring prelude to the good fellowship which centered at the huge rustic clubhouse. Grover C. Dillman, president of the Michigan College of Mining and Technology and general chairman of the District meeting, presided. At the buffet luncheon, President McNamee of the Michigan Section formally welcomed the guests. Then followed the delightful reminiscences of Past-Director George H. Fenkell.

At the Friday morning meeting, Director Louis E. Ayres read a paper dealing with the work of the national Society. Written with extreme care, it was searchingly analytical of the scope and functions of the work now being done. Director James L. Ferebee in leading the discussion stated that he felt the present methods of Society control to be entirely suitable.

At the luncheon, the peninsula's famed dish—the "pasty" of the Cornish miner—was served. Physically it is unique, while gastronomically it is of high order. It might be called a meat-pie turnover, but such plebeian designation hardly does justice to the excellence of the dish.

"The Problem of the Juniors" was the subject to which Director W. W. De Berard and President Henry E. Riggs addressed themselves with vigor and understanding at the afternoon session.

The morning meeting was presided over by Louis J. Larson, president of the Wisconsin Section, while Ralph M. Palmer, president of the Duluth Section, presided in the afternoon.

While this was going on, the ladies were having a most enjoyable time. A bridge tea and get-together took place in the luxurious Faculty Club rooms. Bridge and conversation rivaled for distraction, with the artistic prizes of hammered copper going to the high scores for the former. Mrs. Dillman and her committee proved wonderfully adept in making everyone most happily at home.

The day was concluded by a splendid banquet, made memorable by the presence of such notables as President Henry E. Riggs, Past-President Daniel W. Meade, and Frederick E. Turneaure, the latter an Honorary Member of the Society and for many years dean of the College of Mechanics and Engineering at the University of Wisconsin. The speaker was James McNaughton, president of the Calumet and Hecla Consolidated Copper Company. He spoke on the appropriate subject of copper. It was at this time that President Straub of the Northwestern Section, on behalf of the guests, read the resolution expressing their thanks to President Grover C. Dillman, whose energy and skill as chairman of the Committee on Arrangements had made the meeting such a success.

Activities closed with the Saturday morning cruise on which members were guests of Maj. Albert B. Hones of the Corps of Engineers, U.S.A. on the tug *Sears*. While the tug passed through the Keweenaw waterway, now being dredged and straightened, the members had opportunity to see the huge dredges at work as well as to enjoy the wonderful scenery. The cruise was splendid in still another way—it provided the occasion for many new acquaintanceships as well as visiting with old friends.

When the *Sears* docked, the meeting ended and the members dispersed. They will meet again, for this is but the first of the meetings of District 7. To insure similar gatherings in coming years, a District organization was formed at the Friday afternoon meeting, consisting of the current presidents of the several Sections of the District. Prof. Lorenz G. Straub, president of the Northwestern Section, was selected as chairman and L. C. Wilcoxen of the Michigan Section as secretary-treasurer.

Paper 2000—Transactions, 1867–1938

Of more than mere statistical interest is the passing of the 2,000-mark in the consecutive numbering of technical papers published in Transactions since 1871 (when a group of separates, published in the preceding four years, was assembled as Volume 1). Simple division yields an average of about 28 papers per year.

Transactions, Volume 103, will contain 35 papers, including Paper 2000. A number of discussions and closing discussions will be published for the first time, including:

"Backwater and Drop-Down Curves for Uniform Channels," by Nagaho Mononobe (brief closing comment by the author).

"Measurement of Debris-Laden Stream Flow with Critical-Depth Flumes," by H. G. Wilm, John S. Cotton and H. C. Storey (closure by the authors).

"Prestressed Reinforced Concrete and Its Possibilities for Bridge Construction," by Ivan A. Rosov (closure by the author).

"Practical Application of Soil Mechanics—A Symposium," closing discussions by Spencer J. Buchanan, Stanley M. Dore, and R. K. Hough, Jr.

"Design of Reinforced Concrete in Torsion," by Paul Anderson (discussion by Harold E. Wessman, and closure by the author).

"Solution of Transmission Problems of a Water Distribution System," by Ellwood H. Aldrich (closure by the author).

"Aeration Tanks for Activated Sludge Plants," by S. W. Freese (closure by the author).

"Structural Analysis Based Upon Principles Pertaining to Unloaded Models," by Otto Gottschalk (closure by the author).

The annual address of the President, as presented at the Convention in Salt Lake City, Utah, on July 20, 1938, is printed in full for the first time. President Henry Earl Riggs spoke on "The Relation of the National Society to the Engineering Profession."

The subject of "Standard Practice in Separate Sludge Digestion" has been under extensive research on the part of a committee of the Sanitary Engineering Division. Progress reports have been published at various times, in Civil Engineering and in Proceedings, since 1932. The final report, as now published in Transactions, naturally contains much that has appeared in the progress reports, but seasoned by the suggestions raised in discussion, and simplified and rearranged to bring it as nearly up to date as possible.

Memoirs of deceased members, to the number of 103, are published in a special section including among its biographies the lives of such engineers as Ambrose Swasey, George H. Pegram, Hugh L. Cooper, Alfred D. Flinn, Daniel E. Moran, Jay J. Morrow, R. S. Patton, and Theron M. Ripley.

Special attention is called to the nine or ten items of errata, occupying a scant page at the end of the contents section. These will enable meticulous students of Transactions (especially of Volume 102) to bring their copies still nearer to the perfection that has been the aim of the Committee on Publications.

Finally, the indexes are interesting in that they bear testimony to the constant effort of the committee to publish papers of value to members of each of the 12 Technical Divisions that now are incorporated into the Society. The percentages of the volume of interest to members of these various Divisions are shown in the following tabulation:

Technical Division	Number of Pages	Approx. % of Space in Transactions (2016 Pages)
Construction	550	32
Engineering Economics	403	23
Highways	342	20*
Irrigation	629	37†
Power	690	40†
Sanitary Engineering	211	12
Structural	564	33
Surveying and Mapping	53	3
Waterways	430	25
Soils	415	24
Hydraulics	388	23

* Includes some highway bridge papers.
† Includes some papers on design of dams.

The extent to which the total of the foregoing percentages exceed 100 is a measure of the duplication of interests. Some Divisions, such as City Planning, Surveying and Mapping, Sanitary Engineering, and Highways, seem to be better served by CIVIL ENGINEERING and so their percentage of space in TRANSACTIONS is relatively low.

In size, Volume 103 is also notable. Its 2016 pages exceed numerically any issue since 1929. But in view of a greater condensation of type in the present volume, the actual contents are still greater. In fact the size, speaking in terms of words, is greater than any issue since Volume 83 in 1920, which consisted of about 2,500 pages. Its value to members, however, will be in terms of its wealth of advanced technical information.

TRANSACTIONS for 1938 is now being completed and bound to meet the varying desires of members. The paper-bound copies are to be included with the regular PROCEEDINGS for October, as Part 2, both Parts 1 and 2 being mailed together on October 15. Those ordering more permanent covers, in cloth or half-morocco, will receive only the regular PROCEEDINGS, Part 1, on that date; and their specially bound TRANSACTIONS will come separately, probably early in November.

Anonymous Voters!

MEMBERS will recall that, when returning ballots for nominees to Society offices, it is necessary for the voter to sign his name on the outside envelope. The reasonableness of this Constitutional provision is at once evident, as it keeps the name completely separate from the ballot itself (which is enclosed in a sealed, blank inner envelope) and at the same time enables the good standing of the voter to be checked with Society records.

Mention is made here of the necessity of signing the outside envelope because a number of ballots have recently been returned to Headquarters with no name attached, making them void. These ballots are for the Second Ballot for Official Nominees, mailed to the membership on August 31. To date (September 20), forty blank ballots have been received. As this ballot will not be canvassed until October 15, there is still time for any member who thinks he may be among the absent-minded ones to write in to Headquarters for a duplicate ballot.

Model Registration Law Reprinted

THE Model Registration Law for Professional Engineers and Land Surveyors, as revised in 1937, is now available for distribution to all who are interested. The preceding edition, prepared in 1932 by a group of representatives from interested engineering societies under the leadership of the Registration Committee of the American Society of Civil Engineers, stood without revision for five years. The high regard in which it was held has been evidenced by the appearance of its principal features in the many state laws or amendments adopted since that date—a tribute to the wisdom of the men who drafted that Model Law. The registration situation, however, has been far from static in the years since the Model Law was first produced. Consolidation and clarification of principles, through the results of wide experience in the administration of these laws in many states, have indicated certain desirable changes to bring the Model Law once more fully abreast of the times.

Accordingly, representatives from 17 national societies met in a series of conferences held in March, April, and May 1937, to revise the Model Law. Throughout the series there was frank discussion, constructive criticism and suggestion by the representatives. A draft thus developed was sent to every individual member of every state registration board with a request for comment. The final revision is the result of careful consideration of all the comments received.

The present revised Model Law does not represent a drastic upsetting of the 1932 law. It is the result of intensive study of the advisable changes in that law by an informed and representative group. The method of revision indicates that the revised law should receive wide support.

The current printing carries on its cover the names of the following eight national societies which have approved and endorsed it:

American Society of Civil Engineers, July 19, 1937
American Institute of Consulting Engineers, October 6, 1937
National Society of Professional Engineers, October 9, 1937
American Association of Engineers, October 21, 1937
Society of Naval Architects and Marine Engineers, November 17, 1937
American Society of Heating and Ventilating Engineers, November 19, 1937
American Society of Mechanical Engineers, November 22, 1937
National Council of State Boards of Engineering Examiners, January 4, 1938

Continuing its custom of leadership in the practical as well as the theoretical phases of a problem, the Society provided all the facilities for the conferences and has absorbed the necessary costs, including those of printing. More than 500 copies have been distributed already to engineering societies that it appears should be interested in the registration of engineers, to every member of every state registration board, and to each of the 63 Local Sections of the Society. Copies of the revised Model Registration Law are available from Society Headquarters without charge.

Papers Filed in Library

ATTENTION is called to the following papers, which have been contributed to the Society for filing with the Engineering Societies Library, 29 West 39th Street, New York, N.Y. Charges for photostating will be quoted by the latter organization on request.

ELEVATED TANK STRESSES

SMITH, B. A., late M. Am. Soc. C.E. "Stresses in the Floor of an Elevated Cylindrical Tank and the Intermediate Floors of the Supporting Tower" (18 pages, mostly in handwriting, plus 4 diagrams). This paper deals with the bending moments set up in the floor of an elevated cylindrical water tank supported on a cylindrical tower (usually less in diameter than the tank) and a central column. Towards the close, bending moments in the tower floors are also discussed. The tank floor is assumed to be rigidly fixed to the central column and simply supported on the tower. The paper includes addenda by the author's son, D. B. Smith, of Melbourne, Australia.

BEAM MOMENTS

MERCHANT, WILFRED, "Computation of Moments in Continuous Beams" (8 typewritten pages—about 2,000 words—and 4 pages of diagrams). This paper presents a method for computing moments in continuous beams "which has been found convenient in office practice for several years." It takes advantage of the general ideas of the Cross method, but "reduces the calculations to a form which could be used by a draftsman not understanding moment distribution." Relative movements of supports are not dealt with.

November Issue to Be Given to Students on Request

AGAIN THIS YEAR, each Student Chapter member in good standing will have the privilege of requesting a complimentary copy of the November issue of CIVIL ENGINEERING. Within a few days, approximately 5,000 letters outlining the plan will be forwarded to Faculty Advisers throughout the country, for distribution to the members of their respective Chapters. The student has but to sign and return to Society Headquarters the card he will find enclosed.

In the interest of the students, a number of special features are planned for November. Abstracts of the annual reports of more than a hundred Student Chapters, covering the activities of the school year 1937–1938, will be presented—many of them with illustrations. Announcement will be made of lantern lectures available for the use of the Chapters, including several new subjects, to be ready after the first of November. At least one prize-winning paper from last year's numerous student competitions will also be included. And, finally, among the full-length articles will be several of special interest to the younger men. A brief survey of some of these papers appears in the Items of Interest section of this issue.

Last year more than 70 per cent of the students circularized requested individual copies. It is hoped that this year the return may be even higher.

Activities of the Committee on the Conservation of Water

Abridged from the Report Presented at the Irrigation Division Session at Salt Lake City, July 21, 1938

By HARRY F. BLANEY, CHAIRMAN, COMMITTEE ON CONSERVATION OF WATER

THE Committee on Conservation of Water of the Irrigation Division was organized in 1929 for the purpose of considering the conservation of rainfall and the consumptive use of water by plant life. Since then several changes have been made in the membership, and the field of the committee has been broadened to include other phases of water conservation. The following report is an account of this work to date.

PAST ACCOMPLISHMENTS

Several conferences of engineers, foresters, agriculturists, and research workers have been sponsored by the committee. These conferences were successful in creating a better understanding of the problems confronting each group. The committee acted as a clearing house for research programs and suggested a program for coordinated studies in California by local, state, and federal agencies. The papers presented at two of these meetings were edited and published in mimeographed form as: (1) "Report on Conference on Research Problems in Consumptive Use of Water and Conservation of Rainfall" (March 1930, 125 pages); and (2) "Report on Progress of Conference on Water Conservation," (March 1935, 105 pages). The subjects included consumptive use of water, evaporation, economic use of irrigation water, conservation of flood water by spreading, law of underground waters, erosion control, transportation of debris, safeguards on denuded watersheds, and check dams.

Two papers by members of the committee have been published in the TRANSACTIONS, and a progress report was published in the December 1935 PROCEEDINGS of the Society.

Although the committee has considered problems of general interest in the western states, a large part of its activities have been in the Pacific Southwest, where most of its members are located. Thus in 1936 the executive committee of the Irrigation Division authorized the formation of two sectional committees on water conservation, one in Utah and the other in Arizona.

PRESENT ACTIVITIES

The Utah Sectional Committee met in December 1937, with the chairman of the general committee, to outline its 1938 program and arrange a water conservation conference. This conference was held on July 19, 1938, at Salt Lake City (just preceding the Society's Annual Convention) and nine papers were presented on water conservation. It is hoped that these may be published at an early date.

During the past year, members of the general committee have been unusually busy with their own work and somewhat scattered. Preliminary drafts of two papers were prepared in 1937 and are now being reviewed. Several of the committee members have been connected with water surveys of the National Resources Committee and thus have had an opportunity to broaden their knowledge of water conservation problems in the West.

Conferences held in 1937 by the National Resources Committee of the federal government, to clarify the problems of water conservation and development in the major drainage basins, indicate that the subject of water conservation will be given primary consideration during the next six years in planning multiple-purpose water projects.

In 1937 the executive committee of the Irrigation Division requested the Committee on Conservation of Water to obtain expressions of opinions from engineers in various parts of the West so as to ascertain the significance of water conservation in different regions and the advisability of organizing additional sectional committees.

The committee conducted such an inquiry some months ago by sending out a questionnaire, to 80 members of the Society. The following are typical of the replies to questions about the significance of water conservation.

Pacific Northwest. Water for irrigation in the Pacific Northwest has not yet become as valuable as in the Southwest. The normal yield is ample, except for relatively small and unimportant areas. An occcasional period of drought, however, emphasizes the need of conservation measures. When development begins to approach ultimate possibilities, the urgency of placing those measures in effect will become more clearly recognized. A program aimed at better consumptive use, and emergency schedules for curtailing and rotating deliveries in accordance with adjudicated priorities, must be worked out eventually.

Pacific Southwest. Water conservation in California has included (1) prevention of waste in the storage and conveyance of water; (2) improvements in methods of applying water on the land; (3) the economic use of water, subject, however, to the necessity of leaching soils and of recharging ground-water basins to prevent excessive salinity; and (4) prevention of flood waste. In the south coastal basin the coordination between flood control and water conservation and the ultimate effect upon the local supplies of the importation of water from the Colorado River, should not be overlooked.

Intermountain States. In Utah, water conservation is significant to every phase of urban and rural advancement. Several of the cities now have inadequate supplies for domestic purposes; a significantly large percentage of the irrigated land is inadequately supplied with late-season water; and many of the power plants

Forecast for October "Proceedings"

SETTLEMENT STUDIES OF STRUCTURES IN EGYPT

By Gregory P. Tschebotareff, M. Am. Soc. C.E.
Data and analyses from settlement studies (which are always quite difficult to secure) of newly constructed buildings in Egypt.

PROBLEMS OF RECONSTRUCTING A PIER IN BOSTON HARBOR

By Charles M. Spofford, M. Am. Soc. C.E.
Novel method of rebuilding pile structures, using steel piles protected by concrete deposited within a caisson surrounding the pile groups.

GREAT LAKES TRANSPORTATION

By M. C. Tyler, M. Am. Soc. C.E.; Brigadier General, U. S. Corps of Engineers
Deals with the historical, statistical, and economical aspects of transportation on the Great Lakes.

MECHANICAL STRUCTURAL ANALYSIS BY THE MOMENT INDICATOR

By Arthur C. Ruge, Assoc. M. Am. Soc. C.E. and Ernst O. Schmidt
Describes a simple device for determining the bending moments in models of structural frames due to external loads.

SOLUTION OF EQUATIONS IN STRUCTURAL ANALYSIS BY CONVERGING INCREMENTS

By George H. Dell, Assoc. M. Am. Soc. C.E.
A modified method of iteration in which the computer progressively keeps track of the rate of change of the increments.

ENERGY MASS DIAGRAMS FOR STORAGE PLANT VALUATION

By John W. Hackney, Jun. Am. Soc. C.E.
An exposition of an ingenious semi-graphical method for simplifying computations that are usually very laborious and tedious.

BEAM CONSTANTS FOR CONTINUOUS TRUSSES AND BEAMS

By George L. Epps, Jun. Am. Soc. C.E.
Applies the well-known Muller-Breslow principle to trusses and beams.

do not have enough water for their needs during late fall and early winter months.

In Colorado, water conservation is concerned primarily with the storage of winter and flood flows of streams; development of underground water; control of seepage; prevention of waste in the irrigation of crops, in the distribution of water from streams to canals; and to a lesser extent with watershed management. Snow survey observation might also be considered in this connection.

Western Gulf Area. Texas has a very inequitable distribution of rainfall. Its streams rise in the northern and western semi-arid regions and converge toward the southwestern wet region. Therefore, the whole state would benefit if all runoff from the western and northwestern part could be impounded. The underground waters are of very great importance and their location, amount, and quality should be determined.

Great Plains. Over large areas in the Great Plains, conservation of water is a complex problem because of erratic fluctuations in rainfall and lack of rainfall over long periods of the year. However, it is part of a broader problem, since water use and land use are joint problems. The development of water facilities to promote better land use is important and should include the construction and maintenance of ponds, check dams, wells, pumps, and other minor facilities for water storage and utilization.

Section Committees. As to the advisability of organizing additional sectional committees, replies from Arizona, California, Colorado, New Mexico, Oklahoma, Texas, Utah, and Wyoming indicated there is a need for such action. Replies from Idaho, Nebraska, Oregon, and Washington intimated that sectional or state committees were not necessary owing to lack of interest or to the fact that water conservation problems are already being handled by state planning boards, representatives of the National Resources Committee, or other agencies.

Future Program

Further activities of the Committee on Conservation of Water will depend upon the future policy of the executive committee of the Irrigation Division. If additional sectional committees are formed, perhaps a new general committee should be organized with a membership consisting of the chairmen of the various sectional committees. Under such a proposal, as the need for each new sectional committee developed, its chairman would automatically become a member of the general committee.

Theoretical hydraulics is not considered within the scope of the committee's work. Although its field has been confined primarily to water conservation as related to irrigated agriculture, in some instances other phases have been considered in connection with multiple uses. The following items in their relation to irrigation in the arid areas have been suggested for further committee activities: (1) hydrology (water supply)—its extent, methods of measurement, practices for conserving, factors affecting; (2) irrigation water requirements—needs of different crops, soils, and climates and methods of improving practice; (3) public policies in relation to the conservation and use of water for irrigation; (4) such overlapping into other uses of water in arid areas as may be involved in the preceding items where multiple uses of water may make it impractical to adhere strictly to irrigation lines.

Replies to inquiries made by the committee suggested many studies that should be of local or general interest in western states.

Reports from Arizona indicate that studies in the Lower Colorado River basin might include: (1) evapo-transpiration losses on watershed areas of multiple uses; (2) consumptive use by field crops and stream-bank vegetation on valley areas; (3) surface and ground-water runoff under different watershed conditions; (4) extent of conflict between uses of surface and underground water supplies; (5) use of saline water for irrigation.

Replies from California suggest that further activities should be directed: (1) to the investigation of the economic phase of conservation, having in view the impending importation of supplementary water supplies from the Sierra and from the Colorado River; (2) to the matter of coordinating conservation in the mountains and on the plain; (3) to the necessity of maintaining the physiographical balance in these areas and on the seashore; (4) relation between water and soil conservation.

Colorado desires further information on (1) consumptive uses and return flow; losses through transpiration by non-productive types of vegetation, evaporation losses; losses of water in stream channels; methods of application to irrigated lands; relative value of ground storage and reservoir storage; (2) extension and improvement in methods of measurement and recording; aerial mapping of irrigated and water-consuming areas; studies to determine effect of work of soil conservation upon runoff; (3) snow surveys.

Texas reports that the Society might well be the means of bringing about a more frank and free exchange of information already gathered by the agencies established in states interested in water conservation, and of suggesting new lines of investigation or the continuation of old lines, as the case may be, to make complete the information on this important phase of engineering.

Many suggestions have been made for studies in Utah, such as (1) water application efficiency; (2) more general use of groundwater supplies; (3) utilization of small reservoir sites for storage of surplus water for irrigation; (4) canal and distribution losses; (5) erosion, small-scale flood-control methods, and effect of forests and vegetation upon runoff; and (6) water spreading to recharge underground basins. The Utah Sectional Committee will give these careful consideration.

Suggestions from several states were made that the committee include the use of saline water for irrigation, snow surveys, and soil conservation as a part of its future activities.

In and About the Society

SEVENTEEN Texas members of the Society got together on August 31 for a shore dinner at Corpus Christi and made plans to invite the Texas Section to hold its 1939 spring meeting in that city. Conrad Blucher presided at the after-dinner session, and J. C. Bisset was appointed as chairman of the invitation committee.

* * * *

ANOTHER pin that came back: "About fifteen years ago," writes John C. Hoyt, "while in Glacier National Park, I went to Iceberg Lake, a side trip about eight miles from Many Glacier. On my return I missed my Society pin. Several days later, when registering at a camp about twenty miles distant, the man behind me saw my name and asked if I had lost anything. I told him about the pin and he produced it, saying that he had found it in the trail. It had been stepped on and embedded in the mud, but the gold glittered enough to catch his eye."

Issue of TRANSACTIONS Warrants Discarding of PROCEEDINGS

WITH the appearance of the 1938 TRANSACTIONS during the current month, the perpetual question arises in the minds of some members as to what they may safely do with the accumulated PROCEEDINGS.

At one period, and especially during the depression, it was the practice to make a selective choice as between papers of less permanent value designed for PROCEEDINGS alone, and those of greater permanence and utility intended for both PROCEEDINGS and TRANSACTIONS. Now, however (and for a number of years past), all papers printed in PROCEEDINGS are designed to go eventually into TRANSACTIONS. The only exceptions are progress reports and similar material that is of less permanent importance.

It will be observed that PROCEEDINGS is a transitional stage, and its make-up has been adjusted to suit that purpose. For example, it is bound with only two staples in order to simplify the problem of removing and saving selected parts. In addition, each paper is made to begin with a formal heading, so that when it is removed from PROCEEDINGS its identity as connected with the Society will not be lost.

Papers published in PROCEEDINGS prior to October 1937 were thereafter open for discussion for a number of months. Finally, the authors were permitted to write closing discussion to be included in TRANSACTIONS. The time required for these steps was just about sufficient to enable such papers to form a part of the 1938 TRANSACTIONS. On the other hand, papers published after October 1937 have not had sufficient time for completion and will have to wait one year for inclusion in TRANSACTIONS. The list of all the papers thus omitted from the current TRANSACTIONS will be found at the end of the front index.

With these hints, members can examine their stock of PROCEEDINGS and probably discard all those issues prior to October 1937. Progress reports in the December 1936, January 1937, and March 1937 issues may be detached and retained if desired.

Presidents of the Society

XXXI. JOHN JAMES ROBERTSON CROES, 1834–1906
President of the Society, 1901

WHEN he was 20 years old, John James Robertson Croes did something that was a distinct disappointment to several of his relatives. He decided to become an engineer.

With family pride they had followed his college career, and had pictured him following in the footsteps of his father and grandfather as a clergyman—or as making a name for himself in law or medicine. It was simply taken for granted that he would elect one of the "three learned professions." And now, turning aside from "professional" aspirations, he was taking up an "occupation unworthy of his fine equipment of intellect and education."

JOHN JAMES ROBERTSON CROES
Thirty-Second President of the Society

Whatever the opinion of his family, Croes' choice proved a happy one both for himself and for the other followers of the "unworthy occupation." In the succeeding years he not only won high personal distinction in his chosen field, but contributed much to the enhancement of its standing as a profession.

Croes was born in Richmond, Va., November 25, 1834, of Dutch and Scotch descent. His father was rector of St. John's Church there, and his grandfather the first Protestant Episcopal bishop of New Jersey.

In 1843 the family removed to Terre Haute, Indiana—and it is of interest to note that the best available means of transportation for this transfer was an all-water route from New York, via the Atlantic, the Gulf of Mexico, and the Mississippi, Ohio, and Wabash rivers. Seven years later young Croes returned to the East—via the new Richmond and Indianapolis Railroad—to enter the College of St. James in Hagerstown, Md. From this institution, which is no longer in existence, he was graduated in 1853.

He at once began the study and practice of civil engineering in the offices of practicing engineers, as was then the custom. His first employment was in New Brunswick, N. J., but he soon came to the attention of James Pugh Kirkwood (later President of the Society) and was chosen by him as assistant on the construction of the first water works in Brooklyn, N.Y. Later he was placed in charge of construction on the main reservoir and pumping station, at Ridgewood.

From this engagement he moved across the East River to an assignment on the Croton Water Works Extension of the New York City water supply, and in 1863 he became principal assistant engineer on the water works of Washington, D.C. There he was in charge of completing the aqueduct and the famous Cabin John Bridge, as well as of building the dam at Great Falls.

He returned to New York in 1865 to take part, as principal assistant engineer, in designing and constructing the first storage reservoir to be built for the Croton River water supply. The Boyd's Corners Dam, which formed this reservoir, was the first high masonry dam in the United States. Its design was in the hands of George Sears Greene, and is described in the sketch of General Greene which appeared earlier in this series (October 1936). However, after work on the dam had been in progress for about six months, General Greene was made chief engineer of the entire Croton Aqueduct Department, and Croes was placed in full charge at Boyd's Corners. (His paper describing this dam was published in TRANSACTIONS in 1875 and was the first to be awarded the Norman medal. It is of interest to note that it was written largely on scraps of paper, during waits in railroad stations and at other odd moments.)

By 1870, the Tweed régime had been inaugurated in New York City, and "men of strict integrity and strength of character were an inconvenient factor" in the Aqueduct Department. Accordingly Croes and General Greene were forced to make room for "more congenial" officials.

In 1872 Croes was appointed topographic engineer of the newly created Department of Public Parks, charged with laying out a system of streets and parks, sewerage, and water systems for the newly annexed district that is now the Bronx. Croes was not content to duplicate the crude, strictly rectangular layout of streets that had been adopted for Manhattan in 1811 without regard to topography or convenience. Together with Frederick Law Olmsted, the landscape engineer of the department, he developed a far more satisfactory arrangement that was at once economical and esthetically pleasing. The rectangular system was used where convenient, but curved avenues were introduced wherever grades or costs could be reduced thereby, and systems of parkways connecting well-defined centers were provided for.

For these departures from time-honored system, Croes and Olmsted were subject to considerable criticism—and in some cases to the active hostility of landowners who were wedded to the awkward lot unit of 25 by 100 ft. Their plan, however, was ultimately adopted, and before Croes left the department, in 1879, the actual work of developing it had begun. The street and park system as completed about the turn of the century was substantially in accord with the Croes-Olmsted principles, and still bears witness to their wise foresight.

Croes and Olmsted also presented plans for rapid transit in the annexed district, and Croes later served as chief engineer of one of the lines suggested—the Suburban Rapid Transit Company—from its formation in 1883 until its merger with the Manhattan Company in 1891. This line ran from 129th Street at Second Avenue (Manhattan), across the Harlem River, and up to Tremont—about $3^1/_2$ miles. It was the first of such roads to be located chiefly on its own purchased right of way and so constructed as to admit of running heavy trains at high speed. Its structures and rolling stock were heavier than those of other elevated lines in the vicinity, and it is interesting to note that, as a consequence, it was the only steam road within 50 miles of New York that did not suffer traffic interruptions during the memorable "blizzard of '88."

Except for the chief engineership of this road, Croes' work from 1879 until his death was in private practice—largely as a consultant in the hydraulic field. His reputation in this capacity was so widespread that he received calls from all parts of the country. Special mention should be made of his investigations and studies, during the 1880's, that led to the development of a water supply for Newark, N.J.; his plans for the Syracuse (N.Y.) water supply, made in 1889 and subsequently carried out; and his services as consultant on the Quaker Bridge Dam and the New Croton Dam for the Croton Aqueduct Commission.

Croes wrote easily and well on technical and general subjects. There are 37 entries under his name in the cumulative index to TRANSACTIONS. He also contributed largely to the editorial pages of *The Sanitary Engineer* (later *Engineering Record*) for some ten years, and in 1881–1886 he prepared for *Engineering News* historical and statistical descriptions of the water works of more than 800 American cities. (These statistics were published in book form in 1883, 1885, and 1887, as *The Statistical Tables of American Water-Works*. After these three editions the work was continued in altered form as *The Manual of American Water-Works*, under the editorship of M. N. Baker.)

Croes was among the first of the younger engineers elected to membership in the Society on its reorganization in 1867, and throughout the rest of his life he was enthusiastic in promoting its welfare. He served as Director in 1877, as Treasurer for the following ten years, then as Vice-President (1888), and finally as President, in 1901. In his honor, and to commemorate the first award of the Norman Medal, the Croes Medal was established by the Society in 1912.

He was by nature a man of essentially social tendencies; and his broad education, sense of humor, and varied experience with many classes of men made him an attractive conversationalist. He was also a discriminating lover of music and art.

But social pleasantries had their place—and Croes was not inclined to carry them too far. He was also a man of positive convictions, and when his views were once carefully established he was tenacious of them and a formidable opponent in controversy. "He could never become a courtier, and the flattery he detested to receive he never thought to apply to others, not even in the form of studied deference, which at times might have gained for him professional advantage." A well-founded confidence in his own mental equipment made him largely free from self-consciousness, and thus a good expert witness; the subject in hand so monopolized his thoughts that he could testify without embarrassment regardless of how unfavorable might be the impression he was making.

Croes never married, but he was devoted to the members of his family, and it is said that nothing he ever did for them was ever felt as a sacrifice. The affection was reciprocated, and his home "was made for him a place of charm as well as rest."

For the last ten years of his life Croes was in ill health, yet he continued in active work throughout that period. He died at his home in Yonkers, N.Y., on March 17, 1906.

[This sketch is based on the memoir in TRANSACTIONS, 1907, and on articles in *Engineering News* in 1901 and 1906. All quotations are from the former source.]

Appointments of Society Representatives

CLYDE T. MORRIS, M. Am. Soc. C.E., has accepted an appointment to represent the Society on the Section Committee on Iron and Steel of the Building Code Committee of the American Standards Association.

HENRY E. RIGGS, President Am. Soc. C.E., has been appointed one of the Society's representatives on the John Fritz Medal Board of Award for the four-year term, October 1938 to October 1942.

HAROLD E. WESSMAN, M. Am. Soc. C.E., has accepted an appointment as the Society's representative on the Research Procedure Committee of the Engineering Foundation for the term, October 1, 1938 to September 30, 1939.

News of Local Sections

Scheduled Meetings

CENTRAL OHIO SECTION—Luncheon meeting at the Chittenden Hotel, in Columbus, on October 20, at 12:00 m.

CINCINNATI SECTION—Dinner meeting at the Gibson Hotel on October 4, at 7 p.m., preceded by an inspection trip.

COLORADO SECTION—Dinner meeting at the University Club in Denver, on October 10, at 6:30 p.m.

Dayton Section—Luncheon meeting at the Engineers Club on October 17, 12:15 p.m.

GEORGIA SECTION—Luncheon meeting at the Atlanta Athletic Club, on October 10.

KANSAS STATE SECTION—Dinner meeting at the Kansan Hotel, in Topeka, on October 14, at 6:30 p.m.

LEHIGH VALLEY SECTION—Fall meeting on October 10, at the Packard Laboratory, 8 p.m.

LOS ANGELES SECTION—Dinner meeting at the University Club on October 12 at 6:15 p.m.

MIAMI SECTION—Dinner meeting at the Holsum Restaurant on October 6, at 7:30 p.m.

PHILADELPHIA SECTION—Dinner and meeting at the Engineers Club on October 19, at 6 p.m.; meeting at 7:30 p.m.

SACRAMENTO SECTION—Regular luncheon meetings at the Elks Club every Tuesday at 12:10 p.m.

ST. LOUIS SECTION—Luncheon meeting at the Mayfair Hotel on October 23, at 12:15 p.m.

SAN FRANCISCO SECTION—Dinner meeting at the Engineers Club on October 18, at 5:30 p.m.

SEATTLE SECTION—Dinner meeting at the Engineers Club on October 31, at 6 p.m.

SYRACUSE SECTION—Dinner meeting at the Onondaga Hotel on October 31, at 6:15 p.m.

TENNESSEE VALLEY SECTION—Annual meeting at Knoxville on October 27 and 28; dinner meeting of Knoxville Sub-Section at the University of Tennessee Cafeteria on October 6, at 6 p.m.

Recent Activities

District of Columbia Section

A meeting of the Junior Forum of the District of Columbia Section took place on June 27. During the brief business session a constitution and by-laws were unanimously adopted. The meeting was then turned over to Chandler B. Griggs, who presented a paper on aspects of the U. S. Bureau of Air Commerce that are of interest to the engineer. Mr. Griggs was assisted in his presentation by William Burko.

Panama Section

There were 33 present at a meeting of the Panama Section that took place at the Union Club in Panama City on August 1. The speaker on this occasion was Prof. D. F. MacDonald, who gave an illustrated lecture on the geology of the Isthmus in general, describing particularly the areas where slides occurred during the construction of the canal. A brief business session and discussion of the proposed new by-laws concluded the meeting.

Sacramento Section

A number of interesting speakers were scheduled for the four luncheon meetings held by the Sacramento Section during the month of August. There were 59 present on August 2 to hear Joseph Hyde Pratt, consultant to the U. S. Geological Survey in Washington, D.C., give a talk on topographic mapping in the United States. Speakers at the session held on the 9th were Mark S. Edson, secretary of the Section, and Arthur L. Elliott, of the bridge department of the California State Division of Highways. On the 16th, the speakers were Frederick W. Panhorst, bridge engineer for the State Division of Highways, and J. Osoffsky, a Junior, who discussed the subject, "Percolation Problems on Minor Streams." A talk on pre-stressed concrete was the feature of the meeting held on August 23. This was given by William A. Giddings, also of the State Division of Highways.

San Francisco Section

The San Francisco Section held a regular meeting on August 16, with 130 present and 113 at the dinner preceding the meeting. The program, arranged by the Sanitary Committee of the Section, consisted of talks by G. E. Arnold, chief water purification engineer of the San Francisco Water Department; C. C. Kennedy, consulting engineer of San Francisco; Dr. John P. Russell and Fred Ingram, respectively chief of and engineer for the Industrial Hygiene Service of the California State Department of Public Health; and Dr. Karl F. Meyer, director of the Hooper Foundation for Medical Research, University of California. H. F. Gray served as chairman of the committee that arranged this program.

On July 17 about 20 Juniors and their friends met on the grounds of the California Water Service Company in Woodside, Calif., for their first picnic of the season. On this occasion all kinds of sports were enjoyed, including baseball, horseshoe pitching, and swimming. Arrangements were in charge of Nathaniel J. Kendall, chairman.

Toledo Section

An inspection trip through the partly completed sewage-treatment plant at Detroit, Mich., constituted the August 20th meeting of the Toledo Section. Of major interest was the method of constructing the central pumping station and the 16-ft diameter supply sewer. Due to the fact that many members were away from the city, only eight were able to make the trip. A special luncheon meeting, held on August 13, was attended by 13. The purpose of this gathering was to discuss the proposed "Lake Water Supply Project" and its relation to the engineers of Toledo. Following a résumé and discussion of the subject, the secretary was instructed to send a letter to the city manager of Toledo, suggesting that, in connection with the project, "consideration be given to the employment of Toledo engineers to the fullest extent possible."

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for November

Readers who recall last month's forecast of the content of the current issue are probably wondering what happened to one of the articles selected for specific mention—namely, that by Alton C. Chick. The answer is in the somewhat special nature of the November issue, for which plans had not definitely matured when that forecast was written.

As announced elsewhere in the present issue, copies of Civil Engineering for November will go into the hands of some 3,000 members of Student Chapters. Within a few months many of these students will assume the status of "junior engineer," and will be earnestly seeking opportunities for developing themselves professionally and enlarging their social contacts. Mr. Chick's paper describes the "Rhode Island Experiment"—a local organization for junior engineers specifically designed to provide those opportunities. Young engineers throughout the country may well find in it ideas applicable to their own localities—either through existing Junior Branches of Local Sections, or through the establishment of new junior groups where there are none at present.

From Texas, W. A. Rounds contributes an article on land-surveying, in which he describes some of the difficulties in following the footsteps of the original surveyors. Jerome Fee, in a short and well-written sketch, scans the pages of Samuel Pepys' diary to cull evidence that that famous writer was an expert on the slide rule back in 1662. Robins Fleming looks at building regulations, past and present, in the United States, and poses some thoughtful questions on the framing of future codes.

In the field of structural engineering, a paper by Harry E. Eckles calls attention to important and sometimes-neglected points in the design of retaining-wall footings. Barring a last-minute change of schedule there will also be an article by D. B. Steinman on the construction of the Thousand Islands Bridge—a follow-up on his earlier account of its design, which appeared in June.

An important problem in highway economics is thoroughly reviewed in an article on motor-vehicle taxation rate making, by Lacey V. Murrow and Bertram H. Lindman. Other papers that will be included if space permits have to do with the design and control of concrete, the drainage of irrigated lands, the control of floods, and the design of power plants. Thus a well-rounded issue, with something of interest for every reader, is assured.

Arc Welding Foundation Announces Awards

Prize awards totaling $200,000 were announced on September 15 by the James F. Lincoln Arc Welding Foundation. Second on the list was an award of $11,397.06 to Anant H. Pandya, Jun. Am. Soc. C.E., and R. J. Fowler, for their paper on "The All-Welded Grid Applied to Plane and Spatial Structures." This paper, says the Foundation's announcement, "will doubtless usher in a new era in the design of framing for roofs and floors of buildings." The authors are engineers with Diagrid Structures, Ltd., of London.

The grand award of $13,941.33 went to Mr. and Mrs. A. E. Gibson, respectively president and stockholder of the Wellman Engineering Company, Cleveland, for "an outstanding treatise on all elements required to assure the business and technical success of all users of welding throughout industry."

The Pandya-Fowler paper was an entry in the structural classification. Second place award under that heading ($2,747.39) went to Robert V. Proctor, general manager and chief engineer of the Commercial Shearing and Stamping Company, Youngstown, Ohio. His paper, "Arc Welded Tunnel Liner," describes tunneling with shield and estimates a saving of $15,198,907.00 available on proposed tunnels by use of steel linings. In third place were Howard E. Boath and Charles MacNish, Jun. Am. Soc. C.E., who jointly received $1,526.33 for their paper, "Welding Consciousness in Structural Steel Industry." They are respectively senior engineer and engineer of structural design with the Corps of Engineers, U. S. Army, at St. Louis, Mo. In the same classification an award of $1,526.33 also went jointly to Robert S. Treat, Assoc. M. Am. Soc. C.E., and John F. Willis, M. Am. Soc. C.E., bridge designers, with the Connecticut State Highway Department. Their paper was "Two-Span Rigid Frame for Grade Separation."

Three awards in sub-classes of the structural classification also went to members of the Society. The recipients were Gilbert H. Atwood ("buildings" division), B. M. Shimkin and G. A. Sedgewick jointly (bridges), and John M. Heffelfinger and H. T. Borton jointly (also bridges).

Winners in other classifications included George P. Harber, Jun. Am. Soc. C.E. (third place main award in the "commercial welding" classification); L. M. Davis, Assoc. M. Am. Soc. C.E. (co-winner with J. M. Mousson of third place main award, "functional machinery") and G. C. Munoz, M. Am. Soc. C.E. (co-winner with John F. Muller of first place award in the sub-class, "petroleum making," of the "industry machinery" classification).

Five Thousand Years from Now

By Maurice A. Hecht

Lieutenant (jg), U. S. Coast and Geodetic Survey

As part of their activities at the New York World's Fair, the Westinghouse Electric and Manufacturing Company has buried 50 ft in the ground a metallic "Time Capsule" containing a history of the present time. This container is supposed to remain buried for 5,000 years, then to be recovered and opened in the year 6938 A.D. The contents (selected articles characteristic of our civilization, copies of significant books and documents, and selected motion picture film) will furnish to the people of that time a concrete picture of the cultural development of man up to the twentieth century. In addition to the difficulty of conveying a complete understanding of ourselves in a space only 15 in. in diameter and 6 ft long, and of finding materials that would last for this number of years, the planners of this project were faced with the problem of making it possible to recover the buried capsule.

In order to insure that the Time Capsule could be found even though all landmarks and survey references in the vicinity of New York City were gone in 6938, the U. S. Coast and Geodetic Survey was requested to cooperate by locating the position of this point in such a manner that it would be recoverable. A scheme of triangulation, therefore, was executed by a party in charge of the author from a connection with existing stations of the national net in the vicinity of the New York World's Fair grounds. The observations were adjusted by least squares and the position of the center of the "time well" in which the capsule has been deposited was computed. The latitude, north of the Equator, and the longitude,

The Time Capsule Is Made of a Special Alloy, Harder than Steel and Durable as Copper, and Its Inner Container Is of Glass

Five Thousand Years Hence It Is to Be Recovered and Opened—If the Best Laid Schemes Gang Not A-Gley

west of Greenwich, England, are given to thousandths of a second—one-thousandth of a second representing a distance of slightly over one inch on the earth's surface. This position is coordinated with, and bears a rigid relation to, the more than 50,000 stations of the triangulation net extending over the whole country.

It is only necessary that the seventieth century engineer recover any one or more of the fixed points in this net and extend a scheme of triangulation to the approximate vicinity of the buried capsule. When he knows the latitude and longitude of the approximate point and of the capsule, the problem is reduced to a simple measurement of azimuth and distance. He can then with reasonable assurance say, "Dig here." As an added precaution in case none of the stations can be recovered, a nearby station has been determined by astronomical measurements.

The geodetic coordinates were furnished to Westinghouse and will be included in a book to be published and distributed to all the principal libraries and scientific institutions of the world. The book will also contain a brief description of geodetic surveying as carried on today and will explain the method of using the geodetic coordinates in order to find the capsule.

This example of location is of interest because of the spectacular nature of the point rather than because of the surveying methods employed, which were routine. But it does serve as an example of the permanence and importance of geodetic control to the engineer. It should be of special interest to the entire engineering profession, that a survey has been made for use 5,000 years from now. Most human progress is the result of planning, which must of necessity be projected to a greater or lesser degree into the future—5,000 years more or less.

British Institution Publishes Engineering Abstracts

SINCE January 1938, *Engineering Abstracts*, published monthly by the Institution of Civil Engineers with the cooperation of other engineering societies in Great Britain and the Dominions, have been appearing in a new, sectionalized form. Section 1 ("Engineering Construction") is of special interest to civil engineers, and has been brought to the attention of the Society with the thought that many American engineers may be interested in becoming subscribers.

In preparing the *Abstracts*, some 210 periodicals published in many different languages are regularly examined for the selection of articles and papers containing new and important information in regard to research or to the execution of engineering work. The abstracts are made by a panel of more than fifty translators and abstractors, each dealing with the branches of engineering in which he has practical experience.

The caliber of the engineers who do this work and the value of their product has earned for the abstracts a well-deserved esteem. The volumes are favorably known to many Society members in the previous quarterly and comprehensive form. With the present arrangement of monthly issue, the abstracts become more up to date, and with the improvement of the sectional division, it becomes possible to subscribe to single parts—an advantageous and economical arrangement.

Section 1 covers surveying, engineering physics, structures, operations and methods, railways, docks, harbors, canals, rivers, coastal works, water supply, and water power. The annual subscription rate (12 issues) is 12 shillings—about $3.00—plus postage. All subscriptions run from January. Further information can be secured from the Secretary, the Institution of Civil Engineers, Great George Street, Westminster, London, S. W. 1.

Unique Bridge Construction Depicted

THIS month's "Page of Special Interest" illustrates the various steps in the placing of the first span of the Hawkesbury River Bridge, New South Wales, Australia. (See article on page 682 of this issue.)

The pen-and-ink sketches as reproduced are typical of the better class of newspaper illustrations of fifty years ago, and were taken from a scrapbook of clippings submitted by E. K. Morse, M. Am. Soc. C.E., who was the engineer in charge of the erection. Since the halftone process of reproducing photographs did not come into general use until 1890, it was necessary for an artist to work from photographs or go on location and sketch such projects first hand. The technically accurate and artistic results, as depicted on the Page of Special Interest, serve to remind us of a changing reportorial medium as well as to give us an interesting account of a bridge construction job of fifty years ago.

Brief Notes from Here and There

THE Montana National Bituminous Conference moves into Mississippi this year for its four-day forum on asphaltic highway construction and maintenance. The sessions will be held at Biloxi, beginning on October 10, and should attract many highway engineers for whom attendance at the previous meetings—at Glacier National Park—has been impossible.

* * * *

IN LAST month's item describing De Havilland's arch at Seringapatam, India, the date of collapse was given as 1926. The correct date is 1936.

* * * *

LOCAL residence is being waived by Milwaukee's City Service Commission in its quest for a superintendent and assistant superintendent for that city's new filtration plant. American citizenship only is required. The examinations, which probably will be held about the middle of November, "will be conducted in such a way as to be worthy of the professional nature of the positions, and the professional standing of applicants will be fully protected." Salaries for the two positions are on a sliding scale and begin at $3,600 and $2,700 respectively. Details of procedure are available from the City Service Commission, City Hall, Milwaukee, Wis.

NEWS OF ENGINEERS

Personal Items About Society Members

R. B. NEWMAN, JR., who has been acting chief power project engineer for the PWA at Chattanooga, Tenn., for the past few months, recently received a permanent promotion to that position. Mr. Newman became connected with the PWA in 1933.

CARL B. WIRSCHING, retired civil engineer of Los Angeles, Calif., has been appointed chairman of the Public Works Commission of that city.

W. W. MCCLEVY, district engineer for the Virginia State Department of Highways at Bristol, Va., has been made purchasing agent of the department.

AUGUSTUS R. ARCHER, consulting engineer, and Hobart A. Walker, architect, announce that they have associated for the practice of engineering and architectural work. Their offices are in Somerville and East Orange, N.J.

GEORGE S. KNAPP has been appointed consultant to the Northern Great Plains Committee of the National Resources Committee. He is to serve as executive officer of that committee and as such will coordinate the activities of state and federal agencies dealing with land and water conservation in Montana, Wyoming, North Dakota, South Dakota, and Nebraska. His headquarters are in Omaha, Nebr.

HARVEY S. HURLBURT is now job engineer for the Massman Construction Company on the construction of Pensacola Dam at Vinita, Okla. He was previously resident engineer for the Central Ohio Light and Power Company at Bluffton, Ohio.

ROY P. BISHOP has resigned as town manager of Norton, Va., to accept a position as administrative assistant to the director of the Division of Motor Vehicles, Commonwealth of Virginia, with headquarters in Richmond, Va.

I. T. CHESSON LARNDER, until lately with the Canadian Niagara Power Company, Ltd., at Niagara Falls, Ontario, has accepted a position on the engineering staff of the Demerara Bauxite Company at Mackenzie, British Guiana.

A. C. POLK announces the reopening of his general and consulting engineering office in the P.otective Life Building in Birmingham, Ala. Mr. Polk has recently

been engaged in designing and supervising the construction of an industrial water supply for the city of Birmingham.

LLOYD F. RADER, associate professor of civil engineering at the Polytechnic Institute of Brooklyn, has been awarded the Prize of Belgium in a world-wide competition, sponsored by the Permanent International Association of Road Congresses.

LLOYD F. RADER

This prize, which was established in 1910, is awarded about every four years for the dissertation contributing most to the advancement of highway engineering.

ARTHUR P. SMYTH, previously with the U. S. Bureau of Reclamation at Riverton, Wyo., is now in charge of all construction for the J. G. White Engineering Corporation at Port au Prince, Haiti.

HOMER R. STANFORD now has the rank of rear admiral in the Civil Engineer Corps of the U. S. Navy.

PERRY CRAWFORD has resigned as president of the American Utilities Service Corporation at Savanna, Ill., to become vice-president of the Central Service Corporation, with headquarters in Chicago, Ill.

BERTRAM W. GOODENOUGH recently resigned from the Tennessee Valley Authority to become an engineer for Pacific Constructors, Inc., on the construction of Shasta Dam at Redding, Calif.

CLARENCE E. S. BARDSLEY is taking a year's leave of absence from his position as professor of hydraulic engineering at the Missouri School of Mines and Metallurgy, where he has been on the teaching staff for the past eighteen years, to assume a similar position at Oklahoma Agricultural and Mechanical College.

HARRY P. MCKEAN has resigned his position as head of the Drafting Service Division of the Tennessee Valley Authority to resume his former connection with the Harza Engineering Company, which is engaged on the Santee-Cooper Project at Charleston, S.C.

C. J. ESPY, JR., formerly junior hydraulic engineer for the U. S. Geological Survey at Boise, Idaho, is now a lieutenant (jg) in the Civil Engineer Corps of the U. S. Navy. He is stationed at the Puget Sound Navy Yard, Bremerton, Wash.

BEN L. GRIMES recently resigned as territorial sanitary engineer of Alaska to accept a position with the Oregon State Board of Health under Carl E. Green, state sanitary engineer. His headquarters are in Portland, Ore.

PAUL B. BRENEMAN has announced his retirement as head of the department of mechanics and materials of construction at Pennsylvania State College. Professor Breneman has been connected with the college off and on since 1894, and continuously since 1908.

INGE LYSE has resigned as research professor of engineering materials in charge of the work at the Fritz Engineering Laboratory at Lehigh University to accept the position of professor of reinforced concrete and solid bridges in the Norway Institute of Technology at Trondheim, Norway.

A. D. WILDER, who was recently appointed executive director of the Housing Authority of San Francisco, has now received an appointment as director of works of the city and county of San Francisco.

EDWARD E. WALL, director of public utilities for the city of St. Louis, has just celebrated the fiftieth anniversary of his joining the engineering staff of the city. Because of several years devoted to other work his period of actual service with the city has been forty years. Perhaps Mr. Wall's outstanding achievement during this period has been his work in securing pure water for the city.

F. T. CROWE is now with Pacific Constructors, Inc., as general superintendent on the construction of Shasta Dam at Redding, Calif. He was formerly general superintendent for Six Companies, Inc., on the construction of Parker Dam.

VERNON A. C. GEVECKER, previously connected with the Procter and Gamble Manufacturing Company, in St. Louis, Mo., has accepted a position as instructor in civil engineering at the Missouri School of Mines and Metallurgy.

ALFRED V. BOWHAY is now traffic engineer in the City Engineer's Office, San Francisco, Calif. This represents a promotion over his previous position as civil engineering designer.

EDWARD M. MARKHAM has resigned as commissioner of public works of New York City to become president of the Great Lakes Dredge and Dock Company in Chicago, Ill. General Markham served continuously in the army from 1899—the year of his graduation from West Point—until October 1937, when he retired as chief of engineers, U. S. Corps of Engineers. He assumed his New York post at the time of his retirement.

JOHN STERLING LANE, until lately construction engineer in the Procurement Division of the U. S. Treasury Department at San Francisco, Calif., is now assistant construction engineer in the U. S. Engineer Department of the War Department, Los Angeles (Calif.) District.

JAMES O. BALL has accepted a position as assistant professor of petroleum engineering at the Colorado School of Mines. He was previously with the Standard Oil Company at Casper, Wyo.

CLIFFORD E. PAINE, formerly associated with the late Joseph B. Strauss in the firm of Strauss and Paine, Inc., announces that he will continue his engineering practice under the name of Clifford E. Paine and Associates, Inc., with principal offices at 176 West Adams Street, Chicago, Ill.

C. H. WOLF is leaving the Fargo Engineering Company of Jackson, Mich., to represent George B. Gascoigne and Associates as resident engineer on the Muncie (Ind.) Sewage Treatment Plant.

ENRIQUE J. AGUERREVERE has just been named Minister of Public Works of Venezuela.

ARTHUR A. MCLAREN is now chief engineer of the Seaboard Construction Corporation, with headquarters at Katonah, N.Y. He was formerly an engineer for the Dominion Construction Company, at Niagara Falls, Canada.

MORGAN CILLEY, consulting engineer of Romney, W.Va., is now acting for the town of Romney as city engineer and superintendent on the construction of its sewer system and complete disposal plant.

KAY N. G. SAURBREY, formerly civil engineer for the North Carolina State Highway and Public Works Commission, has been appointed engineer for the Public Works Administration in Washington, D.C.

DECEASED

WILLIAM NOEL ALLISON (Jun. '32) inspector for the U. S. Bureau of Reclamation at Grand Coulee Dam, died at Amarillo, Tex., on July 29, 1938. Mr. Allison, who was 29, was graduated from the University of Washington in 1931. In 1934 he joined the staff of the Bureau of Reclamation.

ARTHUR JEROME BARZAGHI (Assoc. M. '18) who was connected with the New York World's Fair, 1939, Inc., died on July 20, 1938, at the age of 51. From 1913 to 1916 Mr. Barzaghi was secretary and treasurer of Barzaghi-Vought Company, Inc., general contractors of New York City, and from 1916 to 1918 he was treasurer of the Schickel Motor Company. Later he was connected with the Turner Construction Company on the construction of government buildings in Washington, D.C. Mr. Barzaghi joined the staff of the New York World's Fair in 1937.

HORATIO BEVAN BOWERMAN (M. '13) retired chief construction engineer for the U. S. Bureau of Lighthouses, died at his home in Baltimore, Md., on May 12, 1938. At the time of his retirement in 1933 Mr. Bowerman had been in the U. S. Lighthouse Service for 46 years, having entered

it as a draftsman in 1887. He served in various engineering capacities and in 1912 was appointed chief construction engineer. For most of the subsequent period he was associated in directing the Lighthouse Service and establishing it on a firm basis.

GEORGE B. CHRISTIE (M. '95) construction engineer of Chicago, Ill., died on August 1, 1938, in Mobile, Ala., where he had lived recently. He was 75. In 1888 Mr. Christie joined the firm of Rosewater and Christie, which designed and constructed numerous sewerage systems in Nebraska and Kansas. He became a member of the firm of Christie and Lowe in 1898. This firm was active for many years in Chicago and the Mississippi Valley, having worked on the building of the Chicago Drainage Canal, the Mississippi levees, and many other structures.

HARRY WINTER EDWARDS (M. '90) consulting engineer of Ridgefield, N.J., died on August 29, 1938, at the age of 79. From 1880 until 1912 Mr. Edwards was active in railroad engineering work in the West and South. He also made complete valuation of 2,300 miles of railroad for the New York, New Haven and Hartford Railroad and designed docks and warehouses for New York Harbor. In 1912 he established a private engineering practice in New York City, later moving his practice to Ridgefield.

WILLIAM GRAY (Assoc. M. '93) retired civil engineer of Rhinebeck, N.Y., died at Atlantic City, N.J., on August 14, 1938, at the age of 78. Mr. Gray's early experience included surveying work in the United States and Mexico. Beginning in 1886, he was for a number of years in the engineer department of the New York City Aqueduct Commission. And from 1908 until his retirement in 1932 he was assistant engineer in the Borough of Bronx (New York City) Bureau of Sewers.

WALTER EDWIN HART (Assoc. M. '22) office engineer for the Portland Cement Association at Kansas City, Mo., died on August 1, 1938, at the age of 53. Mr. Hart had been with the Portland Cement Association for 21 years—for a number of years as assistant manager of the structural and technical bureau of that organization in Chicago, Ill., and from 1933 to 1935 as manager of the bureau. In the latter year he was made district engineer at Kansas City.

CLARENCE RICKER HOPPER (M. '30) civil engineer and contractor of Douglasville, Ga., died in Veterans' Hospital No. 48, Atlanta, Ga., on July 13, 1938. He was 57. During the war Major Hopper was eighteen months overseas, serving as a captain of the 328th Infantry, 82d Division. Of late years he was active in the Reserve Corps. After the war he spent several years in the Philippines on a water works project. Later Major Hopper was president of the Hopper-Winston Construction Company, of Auburn, Ala. In 1930 he established a general contracting practice in Griffin, Ga., and about a year ago moved to Douglasville.

The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."

LUCIUS SANFORD HULBURD (Assoc. M. '11) superintendent of bridges for the New York State Bridge Authority, died suddenly at Poughkeepsie, N.Y., on September 6, 1938, at the age of 59. Mr. Hulburd began his career in 1904, when he entered the service of New York State in the Department of State Engineer and Surveyor. Later he was resident engineer on the construction of the Barge Canal. He was employed as engineering representative of the state on the construction of the Mid-Hudson Bridge and upon its completion, in 1928, became the operating superintendent. At the time of his death, he also had charge of the operation of the Rip Van Winkle Bridge at Catskill.

ALLAN BENJAMIN LEA (M. '08) engineer of Buenos Aires, Argentine Republic, died there on July 17, 1938, at the age of 72. Mr. Lea was born and educated in Buenos Aires, where he spent his entire life. The early years of his career were devoted to a number of surveying and railroad construction projects. From 1902 to 1906 he was chief engineer in charge of the triangulation and topographical survey of 12,600 square miles in the Territory of Chubut. In 1906 he established the civil engineering practice that he maintained until his death, specializing in surveys and valuations.

CHARLES ARNER RUGGLES (Assoc. M. '02) retired civil engineer, died at his home in Rye, N.Y., on September 6, 1938, at the age of 68. Beginning in 1897, Mr. Ruggles was for a number of years manager of the New York office of the Brown Ketcham Iron Works, of Indianapolis, Ind. For over twenty years he was president of the Ruggles-Robinson Company, a contracting engineering firm in New York City. He retired several years ago.

JOHN G. SULLIVAN (M. '99) former chief engineer of the Canadian Pacific Railway, died at his home in Winnipeg, Canada, on August 7, 1938. He was 75. A native of New York State, Mr. Sullivan gained his early experience in railroad engineering in the West, going to Canada in 1900. From then until 1928, except for two years as assistant chief engineer on the construction of the Panama Canal, he was continuously in the service of the Canadian Pacific. From 1928 until his retirement three years ago, Mr. Sullivan had a private practice in Winnipeg.

GEORGE HUNTINGTON THROOP (Assoc. M. '07) consulting engineer of New York City, died on August 9, 1938, at the age of 62. For many years he was associated with the J. G. White Engineering Company of New York, which he represented in South America, Mexico, and Alaska. For several years he had charge of the company's San Francisco office. During the war he was in charge of engineering supplies for the Second Army. Commissioned a captain, he was later promoted to the rank of lieutenant colonel. In 1934 Colonel Throop left the J. G. White Engineering Company to establish his consulting practice.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From August 10 to September 9, 1938, Inclusive

Additions to Membership

AHERNE, JAMES BARTHOLOMEW (Jun. '38), 3421 One hundred and seventh St., Corona, N.Y.

BLOODGOOD, DON EVANS (Assoc. M. '38), Supt., Dept. of Sanitation, City of Indianapolis, R. F. D. 3, Box 976 H, Indianapolis, Ind.

BOHAC, FRANK JOSEPH (Jun. '38), Bookkeeper and Office Engineer, Inland Construction Co., Box 266, Ord, Nebr. (Res., Tyndall, S.Dak.)

BROWN, FREDERICK RAYMOND (Jun. '38), Junior Engr., U. S. Waterways Experiment Station (Res., 1326 Grove St.), Vicksburg, Miss.

BROWN, JAMES WESLEY (Assoc. M. '38), City Engr. (Res., 301 Virginia Ave.), McComb, Miss.

BROWN, JOHN FRAZEY (M. '38), Engr. in Chg. of Constr., South Works, Carnegie-Illinois Steel Corporation, 3426 East 89th St., Chicago, Ill.

BURGE, EUGENE FIELD (Jun. '38), Junior Highway Engr., State Div. of Highways, 808 State Bldg., Los Angeles, Calif.

BURNHAM, ALONZO KNOWLTON (M. '38), Div. Engr., Great Lakes Dredge & Dock Co., Atlantic Div., 17 Battery Pl., New York, N.Y. (Res., 367 East Madison Ave., Dumont, N.J.)

CAREW, JOHN FRANCIS, JR. (Assoc. M. '38), Res. Engr. Insp., PWA, 29-28 Forty-first Ave., Long Island City, N.Y.

CREMER, RANDALL (M. '38), Vice-Pres., Frederick Snare Corporation, 114 Liberty St., New York, N.Y.

DAMON, HENRY GILROY (Assoc. M. '37), Asst. Engr., Damon & Foster, Chester Pike and High St., Sharon Hill, Pa.

DAVIDSON, HEBERT (Assoc. M. '38), With Bridge Decking Dept., Blaw-Knox Co., Blawnox (Res., 245 Melwood St., Pittsburgh), Pa.

DAVIS, DOUGLAS CHARLES (Jun. '38), Lieut., Corps of Engrs., U.S.A., Acting Director, U. S. Waterways Experiment Station, Vicksburg, Miss.

DERBY, FRANK HOLLIDAY (M. '38), Associate Prof., Civ. Eng. Dept., Washington Univ., St. Louis (Res., 129 South Elm Ave., Webster Groves), Mo.

DONG, YEN HONG (Jun. '37), Care, Mee Wah Book Store, 166 Hon Min Rd., N., Canton, China.

DOUGLASS, WALTER ALBERT (Assoc. M. '38), Asst. to Bridge Constr. Engr., State Highway, Bridge Dept. (Res., 2508 Eighth Ave.), Sacramento, Calif.

ENRIGHT, PAUL MANNING (Assoc. M. '38), Civ. Engr., Hydr. Dredging Co., 1221 Central Bank Bldg., Oakland, Calif.

FARRIS, HOWARD CARL (Assoc. M. '38), Res. Engr., State Div. of Highways, Bridge Dept., Sacramento, Calif.

FERGUSON, GEORGE ERNEST (Assoc. M. '38), Associate Engr., U. S. Geological Survey, Water Resources Branch, Washington, D.C.

FERRER-VAILLANT, ALBERTO (Jun. '38), Asst. Engr., Secretaria de Obras Publicas, Aguilera Alta 4, Santiago de Cuba, Cuba.

FROST, DANIEL CARTER (Assoc. M. '38), Instr., Civ. Eng., Newark Coll. of Eng., 367 High St., Newark, N.J.

FULTON, EDWIN GEORGE (Assoc. M. '38), Engr. and Contr., 217 Board of Trade Bldg., Superior, Wis.

GALLAGHER, CHARLES RICHARD (Jun. '38), Care, Bridge Dept., Div. of Highways, Sacramento, Calif.

GLYNN, FREDERIC STANLEY, JR. (Jun. '38), Testing Engr., Stone & Webster Eng. Corporation, 49 Federal St., Boston (Res., 104 Grant Ave., Medford), Mass.

HALL, WESLEY MILES (Assoc. M. '38), Res. Engr., Brown and Coleman Counties, State Highway Dept., Div. 23, Brownwood, Tex.

HEIN, WALTER EDWARD (Jun. '38), R.F.D. 1, St. Charles, Ill.

HEYKOOP, JAN (M. '38), Chf. Building Engr., Am. Enka Corporation (Res., 5 Lake Drive), Enka, N.C.

JOHNSON, GEORGE PETER (Assoc. M. '38), With Pres., Borough of Manhattan, Div. of Designs, Room 2134 Municipal Bldg., New York, N.Y.

KING, RICHARD (Jun. '38), 1001 Irma St., Brownwood, Tex.

KISHEL, EDWARD FRANK (Jun. '38), Box 193, Virginia, Minn.

KULP, RUSSELL BRENTON (M. '38), Constr. Engr., Tennessee Coal, Iron & R. R. Co. (Res., 4320 Walnut St.), Birmingham, Ala.

NELSON, TOIVO JOHN (Jun. '38), Box 98, Wenatchee, Wash.

NORRIS, JAMES ALEXANDER (Assoc. M. '38), Chf. Engr. and Gen. Supt., Dick-Smith Eng. Corporation, Hazleton (Res., 132 East Dewart St., Shamokin), Pa.

POHL, HERMAN HENRY (M. '38), Maj., Corps of Engrs., U.S.A., Office, U. S. Dist. Engr., Honolulu, Hawaii.

RAUCH, HENRY ALBERT (Jun. '38), Civ. Engr., National Cash Register Co. (Res., 2266 East 5th St.), Dayton, Ohio.

ROLER, HOWARD DIETRICH (Jun. '38), 34-67 Sixtieth St., Woodside, N.Y.

SEXAUER, HARVEY ROBERT (Jun. '38), Engr. Aide, U. S. Dept. of Agriculture, Bureau of Biological Survey, Ankeny, Iowa.

SMITH, EDWARD EPHRAIM (Assoc. M. '38), Gen. Supt., Dept. of Water and Sewage Treatment, City of Lima, 119 West High St., Lima, Ohio.

SMITH, MARLIN ROCKLIUS, JR. (Assoc. M. '38), City Engr., Box 245, Lubbock, Tex.

SOLEM, JOHANNES ERIK (Assoc. M. '38), Supt., Proctor & Gamble, 1967 Golden Ave., Long Beach, Calif.

SPIEGEL, MILTON (Assoc. M. '38), San. Engr., Sewage Equipment Div., Chicago Pump Co. (Res., 6412 North Hoyne Ave.), Chicago, Ill.

STELJES, MARTIN (M. '38), Chf. Engr., Concrete Steel Co., 2 Park Ave., New York (Res., 105 Hill St., New Rochelle), N.Y.

STICKLE, SAMUEL DARK (Assoc. M. '38), Asst. Div. Engr., Atlantic Div., Great Lakes Dredge & Dock Co., New York (Res., 52 Clark St., Brooklyn), N.Y.

STURGEON, MARVIN GENT (Jun. '38), Care, U. S. Bureau of Reclamation, Redding, Calif.

TAYLOR, MARVIN (Assoc. M. '38), Div. Maintenance Engr., State Highway Dept., 930 Martin Bldg., (Res., 1225 South 29th St.), Birmingham, Ala.

TOUR, HARRY BIRD (Assoc. M. '38), Archt., TVA, (Res., 14 East Circle Rd.), Norris, Tenn.

VALENTINE, CLAUDE HENRY (Assoc. M. '38), Deputy Tax Commr., New York (Res., 649 Argyle Rd., Brooklyn), N.Y.

VILLAMIZAR, LUIS CARLOS (Jun. '38), With R. P. Farnsworth & Co., Inc. (Res., 2231 Octavia St.), New Orleans, La.

WATKINS, ROBERT BRUCE (Jun. '38), With Pennsylvania Water Co., Wilkinsburg (Res., 1120 North Highland Ave., Pittsburgh), Pa.

WILKES, KENNETH GEORGE HAROLD (Jun. '38), Junior Civ. Engr., Dept. of Water and Power, City of Los Angeles, Mono Basin Project, Box 401, Leevining, Calif.

WILLIAMS, MELVIN RITCHIE (Assoc. M. '38), Associate Engr., U. S. Geological Survey, Box N, Georgia School of Technology, Atlanta, Ga.

WINKLER, GEORGE SIDNEY (Assoc. M. '38), Eng. and Chf. Insp., City of Eureka (Res., 2621 L St.), Eureka, Calif.

WOODMAN, LORRIN EWART (Jun. '38), 3 Concord Ave., Cambridge, Mass.

WRIGHT, CHESTER FREDRICK (Assoc. M. '38), Civ. Engr.; City Engr., Box 467, Lake Worth, Fla.

YATSKO, MICHAEL (Jun. '38), 528 East 18th St., New York, N.Y.

MEMBERSHIP TRANSFERS

ALEWINE, JAMES K. (Jun. '35; Assoc. M. '38), Res. Engr., Hawley, Freese & Nichols, 407 Capps Bldg., Fort Worth, Tex.

BAGLEY, HARRY HOWE (Jun. '27; Assoc. M. '38), With Turner Constr. Co., 420 Lexington Ave., New York, N.Y. (Res., 215 Terrace Ave., Hasbrouck Heights, N.J.)

BALL, JAMES WESLEY (Jun. '35; Assoc. M. '38), Asst. Engr. in Chg., Hydr. Laboratory, U. S. Bureau of Reclamation, Colorado State Coll. Fort Collins (Res., 750 South Pearl St., Denver), Colo.

BATCHELLOR, JOHN KENNETH (Jun. '30; Assoc. M. '38), Surveyman, U. S. Engr. Office, Gay Bldg., Little Rock, Ark.

BISSET, JOHN CLIFFORD (Jun. '24; Assoc. M. 29; M. '38), City Engr., City Hall, Corpus Christie, Tex.

BOTTOMS, ERIC EDMUND (Jun. '30; Assoc. M. '38), Associate Civ. Engr., U. S. Engr. Office, (Res., 1905 West 19th St.), Little Rock, Ark.

BRACEY, SMITH HERBERT (Jun. '35; Assoc. M. '38), Supt., Marion Const. Co., Nashville (Res., Algood), Tenn.

BROWN, RALPH CHARLES (Jun. '31; Assoc. M. '38), Res. Engr., Railroad Section, TVA, 1103 Highland Ave., Chattanooga, Tenn.

CROSS, WILLIAM PERRY (Jun. '30; Assoc. M. '38), Associate Hydr. Engr., U. S. Geological Survey, Water Resources Branch, 338 Security Mutual Bldg., Binghamton, N.Y.

DAVIS, GEORGE BATTLEY (Jun. '27; Assoc. M. '38), Asst. Engr., U. S. Engrs., Box 253, Vicksburg, Miss.

TOTAL MEMBERSHIP AS OF SEPTEMBER 9, 1938	
Members	5,669
Associate Members	6,178
Corporate Members	11,847
Honorary Members	24
Juniors	3,557
Affiliates	75
Fellows	1
Total	15,504

DUNBAR, T. J., JR. (Jun. '33; Assoc. M. '38), County Engr., Brazoria County, Box 91, Pearland, Tex.

ERICKSON, ERICK BOINE (Jun. '36; Assoc. M. '38), Junior San. Engr., FSA (Res., 4445 Alabama Ave., S.E.), Washington, D.C.

GAMMAGE, CHARLES EDWIN (Jun. '27; Assoc. M. '38), Associate Engr., Southeastern Region, Land Utilization Div., Bureau of Agriculture Economics, U. S. Dept. of Agriculture, 300 Eighth St., N.E., Atlanta, Ga.

GREER, DEWITT GARLOCK (Jun. '27; Assoc. M. '30; M. '38), Chf. Engr., Constr. and Designs, State Highway Dept. (Res., 2508 Jarratt Ave.), Austin, Tex.

HALL, WALTER WILLIAM (Assoc. M. '26; M. '38), Associate Engr., International Boundary Comm., Box 1456, McAllen, Tex.

HARNDEN, HARVEY ADELBERT (Jun. '28; Assoc. M. '38), Care, New York Trap Rock Corporation, 252 Water St., Newburgh, N.Y.

HERRING, FRANCIS WILLIAM (Jun. '21; Assoc. M. '28; M. '38), Executive Director, Am. Public Works Assoc., 1313 East 60th St., Chicago, Ill.

KOHLI, CHARLES BRICE (Jun. '29; Assoc. M. '38), Asst. Civ. Engr., Bureau of Air Commerce, Box 1689, Fort Worth, Tex.

LEIGHTON, CHARLES KELTON (Jun. '33; Assoc. M. '38), Designer, State Highway Dept., 7th Floor, State Highway Bldg., Austin, Tex.

LUSH, CUYLER WARFIELD (Jun. '08; Assoc. M. '10; M. '38), Constr. Engr., Clinton Prison, Dannemora (Res., 95 Court St., Plattsburg), N.Y.

MACRAE, CAMERON FARQUHAR (Jun. '26; Assoc. M. '38), Associate, Whitman, Ransom, Coulson & Goetz, 40 Wall St., New York, N.Y.

MORIN, JOHN ABNER (Jun. '36; Assoc. M. '38), Technical Asst., U. S. Coast Guard, Government Island, Oakland (Res., 2128 Derby St., Berkeley), Calif.

O'BRIEN, DANIEL BERNARD (Jun. '06; Assoc. M. '10; M. '38), Pres., O'Brien Constr. Co., Inc., 104 Madison St., Syracuse, N.Y.

O'BRIEN, MORROUGH PARKER (Jun. '26; Assoc. M. '29; M. '38), Prof., Mech. Eng., Univ. of California, 228 Mechanics Bldg., Univ. of California, Berkeley, Calif.

POPE, THOMAS FLINT (Jun. '36; Assoc. M. '38), With State Div. of Highways, Care, Dist. Engr., Colson-Greathouse Bldg., Paris, Ill.

RADY, JOSEPH (Assoc. M. '27; M. '38), Cons. Engr., 407 Majestic Bldg., Fort Worth, Tex.

ROWE, ROBERT RICH (Assoc. M. '33; M. '38), Archt. and Engr., Montgomery Ward & Co., Constr. Dept., 619 West Chicago Ave. (Res., 6253 Sheridan Rd.), Chicago, Ill.

SEEMANN, ERNEST WARREN (Assoc. M. '28; M. '38), Project Mgr., Merritt-Chapman & Scott Corporation, 17 Battery Pl., New York, N.Y.

SIEGLER, GEORGE (Assoc. M. '31; M. '38), Pres., Chf. Engr. and Gen. Mgr., Geo. Siegler Co., 26 Journal Sq., Jersey City, N.J.

SOLONEWITZ, STANLEY (Jun. '31; Assoc. M. '38), Transitman, Board of Water Supply, City of New York, Kerhonkson (Res., 154 Bradford St., Brooklyn), N.Y.

STINE, WALTER PEARCE (Assoc. M. '12; M. '38), Div. Supt., Gulf Refining Co., Houston Pipe Line Div., Drawer 2871, Beaumont, Tex.

TORIBIO, SIMÉON GALVEZ (Jun. '34; Assoc. M. '38), Prof., Mapua Inst. of Technology; Res. Engr., Philippine Amateur Athletic Federation, Box 1905, Manila, Philippine Islands.

TURNBULL, PAUL HORNE (Assoc. M. '20; M. '38), Engr. and Builder, 325 Valley Rd., Llanerch, Upper Darby, Pa.

WELLS, ROGER MILTON (Jun. '29; Assoc. M. '38), Eng. Insp., Grade 4, Board of Water Supply, City of New York, 346 Broadway (Res., 116 East Mosholy Parkway South), New York, N.Y.

WILLIAMS, HERBERT LESTER (Assoc. M. '31; M. '38), Civ. Engr., U. S. Engr. Dept., 2d New Orleans Dist., Ft. of Prytania St. (Res., 57 Fontainebleau Drive), New Orleans, La.

YOUNG, GUY RAYMOND (Jun. '36; Assoc. M. '38), Asst. Engr., Detroit Rock Salt Co., 12841 Sanders, Detroit (Res., 7234 Kingsley Ave., Dearborn), Mich.

REINSTATEMENTS

HUSSON, WILLIAM MORAGNE, Assoc. M., reinstated Aug. 12, 1938.

RASMUSSON, IRVIN SHERMAN, Assoc. M., reinstated Aug. 10, 1938.

RESIGNATIONS

BUTLER, WELDON COLLINS, Jun., resigned Sept. 2, 1938.

FISHER, HENRY BUFORD, Assoc. M., resigned, Aug. 16, 1938.

FUCHS, ROBERT JOHN, Jun., resigned Aug. 16, 1938.

LEMBERGER, OTTO, Assoc. M., resigned Aug. 25, 1938.

McLAUGHLIN, WILLIAM COLEMAN, Jun., resigned Aug. 29, 1938.

SEXTON, JOHN RODERICK, Assoc. M., resigned Aug. 23, 1938.

SOWER, JAMES EDMUND, Jun., resigned Aug. 25 1938.

Applications for Admission or Transfer

Condensed Records to Facilitate Comment of Members to Board of Direction

October 1, 1938 NUMBER 10

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.

Every member is urged, therefore, to scan carefully the list of candidates published each month in CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

GRADE	GENERAL REQUIREMENT	AGE	LENGTH OF ACTIVE PRACTICE	RESPONSIBLE CHARGE OF WORK
Member	Qualified to design as well as to direct important work	35 years	12 years*	5 years of important work
Associate Member	Qualified to direct work	27 years	8 years*	1 year
Junior	Qualified for sub-professional work	20 years†	4 years*	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years*	5 years of important work
Fellow	Contributor to the permanent funds of the Society			

* Graduation from an engineering school of recognized reputation is equivalent to 4 years of active practice.
† Membership ceases at age of 33 unless transferred to higher grade.

The fact that applicants refer to certain members does not necessarily mean that such members endorse.

ADMISSIONS

MEMBER

EDWARDS, GAIL PHILLIPS, Malden, Mass. (Age 42.) Laboratory Coordinator, San. Eng. Div., Massachusetts Dept. of Public Health. Refers to H. P. Eddy, Jr., A. L. Fales, F. H. Kingsbury, B. F. Snow, J. P. Wentworth, A. D. Weston, R. S. Weston.

EHLERS, VICTOR MARCUS, Austin, Tex. (Age 53.) Director, Bureau of San. Eng., Texas State Dept. of Health. Refers to C. G. Gillespie, J. B. Hawley, H. R. F. Helland, H. E. Miller, E. D. Rich, A. Wolman.

GARRITY, LEO VALENTINE, Detroit, Mich. (Age 39.) Associate Civ. Engr., Dept. of Public Works, City of Detroit. Refers to G. H. Fenkell, L. M. Gram, W. S. Housel, L. G. Lenhardt, H. E. Riggs, F. E. Simpson.

JOHNSON, CHARLES FRANKLIN, Louisville, Ky. (Age 41.) Senior Engr., Commrs. of Sewerage. Refers to M. P. Adams, W. J. Carrel, W. M. Caye, R. W. Hunter, H. A. Pulliam, J. R. Rumsey, D. V. Terrell.

LYMAN, ALBERT KUALII BRICKWOOD, Boston, Mass. (Age 53.) Colonel, Corps of Engrs., U. S. Army, being Dist. Engr., supervising dredging and breakwater construction. Refers to E. L. Daley, C. W. Kutz, J. C. H. Lee, E. M. Markham, T. M. Robins, M. C. Tyler.

McCOACH, DAVID, JR., New York City. (Age 51.) U. S. Dist. Engr. Refers to E. L. Daley, J. C. H. Lee, E. M. Markham, L. C. Sabin, C. H. Tompkins.

McMATH, ROBERT RAYNOLDS, Detroit, Mich. (Age 47.) Pres., Motors Metal Mfg. Co.; also Director, McMath-Hulbert Observatory, Univ. of Michigan. Refers to A. Dow, G. H. Fenkell, L. M. Gram, W. R. Kales, W. Pope, H. E. Riggs.

MOSER, ERWIN ULRICH, Logan, Utah. (Age 39.) City Engr. Refers to H. S. Carter, G. D. Clyde, E. B. Feldman, O. W. Israelsen, C. E. Painter, K. C. Wright.

READING, OLIVER SCOTT, Washington, D.C. (Age 44.) Hydrographic and Geodetic Engr., U. S. Coast and Geodetic Survey. Refers to C. H. Birdseye, W. Bowie, L. O. Colbert, C. L. Garner, T. P. Pendleton, G. T. Rude, P. C. Whitney.

SMITH, HUBERT SHIRLEY, Calcutta, India. (Age 37.) Engr. (Sub-Agent), Cleveland Bridge & Eng. Co., Ltd., Darlington, England, on New Howrah Bridge, Calcutta. Refers to R. Freeman, A. J. S. Pippard. (Applies in accordance with Sec. 1, Art. I, of the By-Laws.)

WESKE, RICHARD FERDINAND, San Francisco, Calif. (Age 44.) Res. Engr., PWA. Refers to T. C. Adams, R. K. Brown, E. B. Feldman, W. C. Hammatt, R. A. Hart, F. H. Richardson, G. H. Taylor.

WOLFE, THEODORE, Cleveland, Ohio. (Age 35.) Structural Engr. and Designer, Cuyahoga County Bridge Dept. Refers to C. P. Fortney, C. G. French, C. T. Morris, F. L. Plummer, R. N. Shepard, W. J. Watson.

ASSOCIATE MEMBER

BARNES, JAMES NEWTON, St. Louis, Mo. (Age 33.) Jun. Engr., U. S. Engr. Office. Refers to E. C. Constance, E. M. Kniestedt, T. A. Middlebrooks, P. S. Reinecke, F. C. Snow.

BARTON, JASON EDWARD, Jefferson City, Mo. (Age 33.) Designer, Missouri State Highway Dept. Refers to R. W. Brooks, C. W. Brown, J. B. Butler, N. W. Remley, S. M. Rudder, E. C. L. Wagner.

BURKE, JAMES BASTION, Springfield, Mass. (Age 28.) Member of firm, Harrison G. White, Cons. Engrs. Refers to E. E. Lochridge, J. E. Perry, C. M. Slocum, L. C. Urquhart, R. R. Zipprodt.

CEPOLA, ANSELM, Yonkers, N.Y. (Age 31.) Instructor in Drafting, Coll. of City of New York; Refers to L. A. Ball, J. M. Garrelts, S. Hardesty, A. Hedefine, H. J. Plock.

CHRISTENSEN, NEPHI ALBERT, Ft. Collins, Colo. (Age 35.) Dean of Eng., Colorado State Coll. of Agriculture and Mech. Arts. Refers to F. J. Converse, R. T. Knapp, R. R. Martel, F. Thomas, L. R. Van Hagan, V. A. Vanoni.

COTTON, JAMES ARNOLD, Brady, Tex. (Age 28.) Asst. Engr., U. S. Engr. Dept. Refers to A. L. Lane, J. T. L. McNew, E. H. Marks, M. C. Nichols, T. Twichell.

EISENHUTH, HAROLD PAUL, Denver, Colo. (Age 35.) Asst. Engr., U. S. Geological Survey, Water Resources Branch. Refers to E. W. Burritt, H. D. Comstock, R. Follansbee, N. C. Grover, C. G. Paulsen, J. D. Quinn.

EMPEY, LEROY WILLIAM, Green Bay, Wis. (Age 33.) Asst. Div. Engr., Wisconsin State Highway Comm. Refers to W. C. Buetow, H. F. Janda, O. C. Rollman, M. W. Torkelson, L. F. Van Hagan.

FARRAR, NADIM, Harrisburg, Pa. (Age 35.) Asst. Engr., PWA. Refers to W. S. Lohr, I. W. Pugh, H. T. Rights, F. C. Stehle, H. A. Wistrich.

FITZGERALD, JOHN PAUL, Jamaica, N.Y. (Age 32.) Asst. Engr., Eng. Design Sec., WPA. Refers to L. W. Clark, T. R. Lawson, L. Levine, H. C. Paddock, S. E. Stott.

HILL, WILLIAM BEANS, Reno, Nev. (Age 38.) Road Engr., U. S. Indian Service, on location, design and construction. Refers to W. H. Bosier, C. V. Bryans, H. J. Doolittle, R. S. Eyre, A. N. Johnson, D. J. Rierdon, S. S. Steinberg.

LEWEY, ERNEST BANE, Washington, D.C. (Age 33.) With U. S. Coast & Geodetic Survey on offshore survey, in charge of ship hydrographic watch, etc. Refers to J. T. Jarman, L. P. Raynor, R. L. Schoppe, O. W. Swainson, C. M. Thomas.

LOCKWOOD, JOHN DONALD, New Orleans, La. (Age 45.) Asst. State Director, Div. of Operations, WPA. Refers to J. F. Coleman, H. M. Gallagher, F. P. Hamilton, W. T. Hogg, J. A. McNiven, A. J. Negrotto, J. Riess.

MASON, CLINTON KENNETH, Keene, N.H. (Age 34.) Supt. and Divisional Constr. Engr., New Hampshire Highway Dept. Refers to J. W. Childs, F. E. Everett, L. F. Johnson, J. O. Morton, A. E. White.

TODD, NORMAN HAGEN, Denver, Colo. (Age 38.) Chief. of Party, Colorado State Highway Dept. Refers to P. S. Bailey, F. C. Carstarphen, E. H. Dauchy, S. B. Lamb, J. B. Maloney, F. M. Okey.

TRIECE, GEORGE HENRY, Baltimore, Md. (Age 38.) Materials Engr., Maryland State Roads Comm. Refers to W. E. Bailey, W. J. Carroll,

P. L. Fahrney, H. S. Mattimore, H. H. Miller, T. Pealer, P. W. Woodring.

JUNIOR

ANGELOS, PETER, New York City. (Age 21.) Refers to W. Allan, R. E. Goodwin.

BADER, JOHN ADOLF, Media, Pa. (Age 22.) Refers to H. L. Bowman, S. J. Leonard.

BAKER, GEORGE MILFORD, Media, Pa. (Age 22.) Refers to H. L. Bowman, S. J. Leonard.

BOSTWICK, EMERSON HUGH, Galloway, Ohio. (Age 23.) Refers to C. T. Morris, R. C. Sloane.

BROD, HOWARD WILLIAM, Los Angeles, Calif. (Age 28.) With Hydr. Sec., U. S. Engr. Dept., on general hydraulic designs, reports, etc. Refers to E. J. Bednarski, A. S. Kemman, E. C. LaRue, T. G. MacCarthy, D. W. Morrison, C. C. Rossi.

CARTER, LAUREN DEANE, Little Rock, Ark. (Age 20.) Refers to N. B. Garver, W. R. Spencer.

CHAN, LOUIS, Oakland, Calif. (Age 24.) Refers to R. E. Davis, C. Derleth, Jr., F. S. Foote, B. Jameyson, C. T. Wiskocil.

CHRISTMAN, FRANCIS SHERMAN, Akron, Ohio. (Age 27.) Refers to J. W. Bulger, R. C. Durst, R. E. Rohn.

CLARK, MARION JAY, Salt Lake City, Utah. (Age 28.) Draftsman-Designer, Utah State Road Comm. Refers to T. C. Adams, M. Housecroft, R. G. Ketchum.

COCOLICCHIO, ERNEST WILLIAM, New York City. (Age 23.) Refers to J. J. Costa, A. V. Sheridan.

CONANT, LEWIS FLEET, Los Angeles, Calif. (Age 27.) Designer and Draftsman for S. B. Barnes. Refers to S. B. Barnes, M. F. Deering, R. J. Kadow, J. O. Oltmans.

CROCKETT, ARGYLE CAMPBELL, JR., Atlanta, Ga. (Age 24.) Refers to R. P. Black, C. D. Gibson, F. C. Snow.

DOHN, CHARLES WALTER, Ridgewood, N.Y. (Age 21.) Timekeeper and Eng. Asst., Johnson, Drake & Piper, Inc., Freeport, N.Y. Refers to R. C. Brumfield, J. P. J. Williams.

DOMASKIN, DAVID ARTHUR, Pembina, N.Dak. (Age 26.) Rodman, North Dakota State Highway Dept., also acting as Chainman, Draftsman and Materials Checker. Refers to A. Boyd, E. F. Chandler.

DOYLE, WILLIAM AUGUSTUS, Berkeley, Calif. (Age 20.) June 1938 to date Axeman, U. S. Engrs. Refers to B. Jameyson, C. T. Wiskocil.

DRAKE, ALFRED C, Blairstown, N.J. (Age 26.) Refers to H. G. Payrow, C. H. Sutherland.

DUBERG, JOHN EDWARD, New York City. (Age 20.) Refers to J. J. Costa, A. V. Sheridan.

DUDER, JOHN SCHMALZ, Salt Lake City, Utah. (Age 22.) Jun. Engr., Mountain Fuel Supply Co. Refers to T. C. Adams, R. B. Ketchum.

ELKMAN, SIDNEY, Portsmouth, N.H. (Age 22.) Inspector under W. Raphael, Colonial Beacon Oil Co. Refers to H. L. Bowman, S. J. Leonard.

ERLENKOTTER, ROBERT, Fort Belvoir, Va. (Age 26.) 1st Lieut., Corps of Engrs., U. S. Army. Refers to F. J. Seery, L. C. Urquhart.

FENTON, GRACE ELLEN (MISS), Lewiston, Idaho. (Age 25.) Computer, Bureau of Highways, being Asst. to Office Engr. Refers to J. E. Buchanan, I. N. Carter, J. W. Howard, W. P. Hughes.

FLANAGAN, THOMAS SCOTT, Philadelphia, Pa. (Age 24.) Refers to H. L. Bowman, S. J. Leonard.

FRISIUS, EDWARD NATHANIEL, Hollywood, Calif. (Age 22.) Refers to R. R. Martel, W. W. Michael.

GALLIGAN, WILLIAM BARTHOLOMEW, New York City. (Age 21.) Refers to J. J. Costa, A. V. Sheridan.

GENTHON, VINCENT PAUL, Clifton, N.J. (Age 21.) Refers to J. J. Costa, R. M. Genthon.

GRIFFIS, LEVAN, Pasadena, Calif. (Age 22.) Refers to F. J. Converse, R. R. Martel, H. Rouse, F. Thomas, D. R. Warren.

HARKER, HERBERT WEESE, Niagara Falls, N.Y. (Age 22.) Refers to W. S. Lohr, L. Perry, P. P. Rice, E. H. Rockwell, G. F. Roehrig.

HOLMES, ROBERT STRATTON, New Haven, Conn. (Age 25.) Fellow in Bureau for Street Traffic Research, Yale Univ. Refers to C. D. Gibson, R. D. Jordan, F. C. Snow.

HOLTER, CHARLES ERSKINE, Woodbury, N.J. (Age 25.) Draftsman, Sewerage Dept., Perring & Remington Co., Camden, N.J. Refers to H. L. Bowman, S. J. Leonard.

HURST, HAROLD ELVIN, Miles City, Mont. (Age 23.) Refers to G. E. Hawthorn, R. G. Hennes, A. L. Miller, C. C. More, F. H. Rhodes, Jr., F. C. Smith, R. B. Van Horn.

JONES, WILSON BURDETTE, Alhambra, Calif. (Age 22.) Jun. Eng. Aid, being Asst. Res. Engr. on Construction, California State Bridge Dept. Refers to R. D. Thorson, D. R. Warren.

KREJCHIK, GLENN CHARLES, Lancaster, Pa. (Age 21.) With Wisconsin Highway Comm. Refers to H. F. Janda, L. H. Kessler, L. F. Van Hagan.

KREML, EDWARD KLEMENT, Baltimore, Md. (Age 29.) Topographic Draftsman, Maryland State-Wide Highway Planning Survey. Refers to T. F. Comber, Jr., H. E. Horstmyer, F. W. Medaugh.

KROC, RICHARD JOHN, New York City. (Age 20.) Refers to W. Allan, R. E. Goodwin.

LANG, THOMAS ARTHUR, Melbourne, Victoria, Australia. (Age 28.) Asst. Engr., State Rivers and Water Supply Comm. Refers to H. Conradi, L. R. East, A. G. Gutteridge, C. H. Kernot, C. W. N. Sexton.

LARSSEN, GEORGE EDWARD, Beatrice, Nebr. (Age 23.) Refers to O. J. Baldwin, R. B. Kittredge, B. J. Lambert.

LELAND, RAYMOND IRVING, Canton, Ill. (Age 22.) Proportioning Engr., Kinsey Eng. Co. Refers to H. E. Babbitt, J. J. Doland, W. A. Oliver, G. W. Pickels.

LEMKE, ARTHUR ATHNIEL, Chicago, Ill. (Age 25.) Instructor in Civ. Eng., Lewis Inst. Refers to J. G. Bennett, D. C. Jackson, Jr., H. F. Janda, L. F. Van Hagan.

MACEDONIA, CHARLES MICHAEL, New York City. (Age 24.) Refers to J. J. Costa, A. V. Sheridan.

MCCARTHY, JOHN TIMOTHY, New Rochelle, N.Y. (Age 22.) Refers to J. J. Costa, J. E. Gibbons, A. V. Sheridan.

MCLEA, DUNCAN KENNEDY, Ames, Iowa. (Age 26). Civ. Eng. Dept., Iowa State Coll. Refers to J. S. Dodds, A. H. Fuller, E. J. Hamlin, F. Kerekes, R. A. Moyer, W. G. Sutton.

MAZURKIEWICZ, SIGMUND, BROOKLYN, N.Y. (Age 23.) Refers to R. C. Brumfield, F. E. Foss.

MERCHANT, WILFRED, Cambridge, Mass. (Age 26.) Graduate student, Massachusetts Inst. of Technology. Refers to C. B. Breed, W. M. Fife, C. M. Spofford, D. W. Taylor, J. B. Wilbur.

MIANO, SANTO, Brooklyn, N.Y. (Age 23.) Jun. Draftsman, Planning Div., WPA. Refers to R. E. Goodwin, W. L. Willig.

MONARCHI, JOSEPH, Columbus, Ohio. (Age 22.) Drafting and Design, Ohio Div. of Conservation. Refers to C. T. Morris, J. C. Prior, J. R. Shank, C. E. Sherman, R. C. Sloane.

MORRIS, MAX HYMAN, New York City. (Age 21.) Topographical Draftsman, Grade 3, Sewers & Highways Div., Borough of Manhattan. Refers to R. E. Goodwin, W. L. Willig.

MOWBRAY, ALEXANDER CLIFTON, Philadelphia, Pa. (Age 21.) Refers to H. L. Bowman, S. J. Leonard.

NICKEL, JACK BOWMAN, Indianapolis, Ind. (Age 26.) Asst. Engr., Indiana State Board of Health. Refers to R. E. Hutchins, H. E. Miller, B. A. Poole, C. E. Williams.

NUERNBERGER, GEORGE FREDERICK, Wauwatosa, Wis. (Age 24.) Sr. Eng. Aid, State Highway Comm. of Wisconsin, acting as Rodman, Chainman, Instrumentman, and Inspector. Refers to B. E. Brevik, F. L. Dieter.

OBERLE, FRANCIS NICHOLAS, Richmond Hill, N.Y. (Age 21.) Refers to J. J. Costa, A. V. Sheridan.

OLIN, SEXTON ARTHUR, Chicago, Ill. (Age 23.) Refers to H. E. Babbitt, W. C. Huntington.

PERLA, PETER GEORGE, Iron Mountain, Mich. (Age 24.) Refers to W. C. Polkinghorne, E. P. Wiedenhoefer.

RAYMOND, HENRY SHERRICK, Chin Lee, Ariz. (Age 24.) Trail Locater, CCC-I.D. Refers to F. C. Kelton, W. W. Lane, R. V. Leeson.

RICHARDSON, ROBERT LLEWELLYN, Sacramento, Calif. (Age 29.) Jun. Steel Inspector, Testing Laboratory, California State Div. of Highways. Refers to R. E. Davis, R. M. Morton, A. A. M. Russell, R. H. Stalnaker, T. E. Stanton, Jr., W. E. Stoddard, R. A. Tudor.

ROSSANO, AUGUST THOMAS, JR., New York City. (Age 22.) Refers to R. W. Carlson, J. D. Mitsch.

ROZELLE, NEWELL ARTHUR, Ithaca, N.Y. (Age 21.) Refers to E. F. Berry, L. Mitchell, S. D. Sarason.

SEAR, THOMAS BENJAMIN, Joliet, Ill. (Age 23.) Engr., Bethlehem Steel Co., Chicago, Ill. Refers to W. C. Huntington, T. C. Shedd, F. M. White.

SHULTZ, RICHARD PAUL, Ann Arbor, Mich. (Age 25.) Refers to R. L. Morrison, C. O. Wisler.

SISKIND, ALFRED, Far Rockaway, N.Y. (Age 20.) Field Engr., Parker Wrecking Co., New York City. Refers to W. Allan, R. E. Goodwin.

SKRLA, THOMAS BRANCH (Dick), Ganado, Tex. (Age 23.) Refers to J. T. L. McNew, T. A. Munson, J. J. Richey, E. W. Steel.

SMIDL, JAMES GEORGE, Chicago, Ill. (Age 23.) Draftsman (Map) and Traffic Analyst, Illinois State Highway Dept. Refers to J. C. Penn, S. M. Spears, R. L. Stevens.

SMITH, ROBERT EARL, Dayton, Ohio. (Age 22.) Refers to C. J. Belz, E. O. Brown, J. J. Chamberlain, Jr., B. T. Schad.

SOUTH, GEORGE PEART, Lehi, Utah. (Age 27.) Refers to H. S. Carter, G. D. Clyde, O. W. Israelsen, H. R. Kepner, M. T. Wilson.

STERN, SYLVAN PHILIP, Philadelphia, Pa. (Age 24.) Refers to H. L. Bowman, S. J. Leonard.

STEVENSON, DEWITT ALEXANDER, Atlanta, Ga. (Age 22.) Refers to R. P. Black, C. D. Gibson.

TANTILLO, CHARLES JOSEPH, New York City. (Age 22.) Refers to J. J. Costa, A. V. Sheridan.

TEUSCHER, IVAN MAXWELL, Logan, Utah. (Age 26.) With Bureau of Reclamation on topography, field, and office work. Refers to H. S. Carter, G. D. Clyde, O. W. Israelsen, H. R. Kepner.

THOMAS, ROBERT OLIVER, Los Angeles, Calif. (Age 26.) Jun. Engr., Transportation Eng. Board, acting as Asst. Engr. to Cons. Engr. on research and investigation re economic conditions, etc.; 1st Lieut., Coast Artillery Corps, Reserve. Refers to D. M. Baker, S. Baker, E. R. Bowen, F. W. Pore, H. E. Smutz, O. A. Stone.

TRACZEWSKI, STANLEY EDWARD, Jersey City, N.J. (Age 21.) Refers to H. N. Lendall, P. S. Wilson.

VITOLO, FRANCIS ADAMS, New York City. (Age 22.) Asst. Field Engr., Cauldwell-Wingate & Co. Refers to L. V. Carpenter, T. Saville, C. T. Schwarze, D. S. Trowbridge, H. E. Wessman.

WAGNER, FRANCIS VINCENT, New York City. (Age 22.) Refers to J. J. Costa, A. V. Sheridan.

WAGNER, VICTOR KAREL, JR., Vicksburg, Miss. (Age 22.) Refers to J. C. Bridger, S. J. Buchanan, D. M. McCain, O. H. Meyer, W. J. Rowland.

WEINER, DANIEL JEANNOT, Baltimore, Md. (Age 24.) Refers to T. F. Comber, Jr., T. F. Hubbard, F. W. Medaugh, J. T. Thompson, A. Wolman.

WILSON, MELVIN ELIAS, New York City. (Age 21.) Refers to J. J. Costa, A. V. Sheridan.

WISHART, ARCHIE, Sharon, Pa. (Age 22.) Refers to C. G. Dunnells, C. B. Stanton.

FOR TRANSFER

FROM THE GRADE OF ASSOCIATE MEMBER

AROSEMENA, LEOPOLDO, Assoc. M., Panama, Panama. (Elected Dec. 3, 1926.) (Age 49.) Secy. of Govt. and Justice (Prime Minister); also Cons. Engr. for Fire Prevention Bureau of City of Panama. Refers to G. E. Edgerton, M. E. Gilmore, W. B. Godfrey, R. C. Jones, T. B. Monniche, L. B. Moore, E. S. Randolph.

BROWN, JOHN MAUGHS, Assoc. M., Minneapolis, Minn. (Elected June 4, 1913.) (Age 54.) Dist. Highway Engr., U. S. Indian Service. Refers to J. Berg, H. S. Carter, L. J. Charles, H. J. Doolittle, F. J. Grumm, J. E. Kirkham, W. P. Linton.

DILLARD, JOHN LEA, Assoc. M., Columbus, Ohio. (Elected June 1, 1904.) (Age 61.) Gen. Mgr. & Pres., The Sturm & Dillard Co., Gen. R. R. Contrs. and Producers of Sand and Gravel in Indiana and Ohio. Refers to G. D. Brooke, C. W. Johns, W. Michel, J. L. Richmond, G. R. Smiley, F. P. Turner, W. P. Wiltsee.

HAMILTON, WILLIAM HENRY, Assoc. M., Denver, Colo. (Elected Junior Oct. 1, 1926; Assoc. M. June 9, 1930.) (Age 37.) Associate Engr., Federal Power Comm. Refers to F. L. Adams, C. W. Fowler, R. B. McWhorter, J. C. Page, T. B. Parker, A. B. Reeves, C. A. D. Young.

N.Y. (Age
chell, S. D.

(Age 23.)
cago, Ill.
C. Shedd,

or, Mich.
on, C. O.

Y. (Age
Co., New
Goodwin.

ado, Tex.
ew, T. A.

(Age 23.)
st, Illinois
C. Penn

(Age 22.)
J. Cham-

(Age 27.)
de, O. W.
n.

Pa. (Age
Leonard.

lanta, Ga.
D. Gibson.

ork City.
Sheridan.

ah. (Age
on topog-
s to H. S.
en, H. R.

les, Calif.
tion Eng.
Engr. on
nic condi-
ry Corps.
S. Baker,
utz, O. A.

sey City,
Kendall, F.

ity. (Age
Wingate &
T. Saville,
e, H. E.

ork City.
Sheridan.

urg, Miss.
S. J. Bu-
ver, W. J.

Md. (Age
F. Hub-
mpson, A.

ty. (Age
dan.

22.) Re-

ATE

Panama.
(Age 49.)
Minister);
Bureau of
Edgerton,
C. Jones,
Randolph.

nneapolis,
(Age 54.)
Service.
Charles,
Kirkham,

bus, Ohio.
Gen. Mgr.
Gen. R. R.
Gravel in
Brooke,
mond, G.
e.

Denver,
; Assoc.
ate Engr.,
Adams,
C. Page,
Young.